BACKGROUND RADIOACTIVITY IN THE SCALER MODE TECHNIQUE OF THE ARGO-YBJ DETECTOR

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South West Jiaotong University, Chengdu
Tibet University, Lhasa
Yunnan University, Kunming
HeBei Normal University,Shijiazhuang

P.Salvini @ECRS 2010 for the coll.

Physical Goals

multi-purpose experiment

- Sky survey - (γ-sources, anisotropies)
- flaring activity (γ-sources, GRBs, solar flares)
- C.R. 1 TeV → 10^4 TeV
- p/p at TeV energies
- hadronic interactions

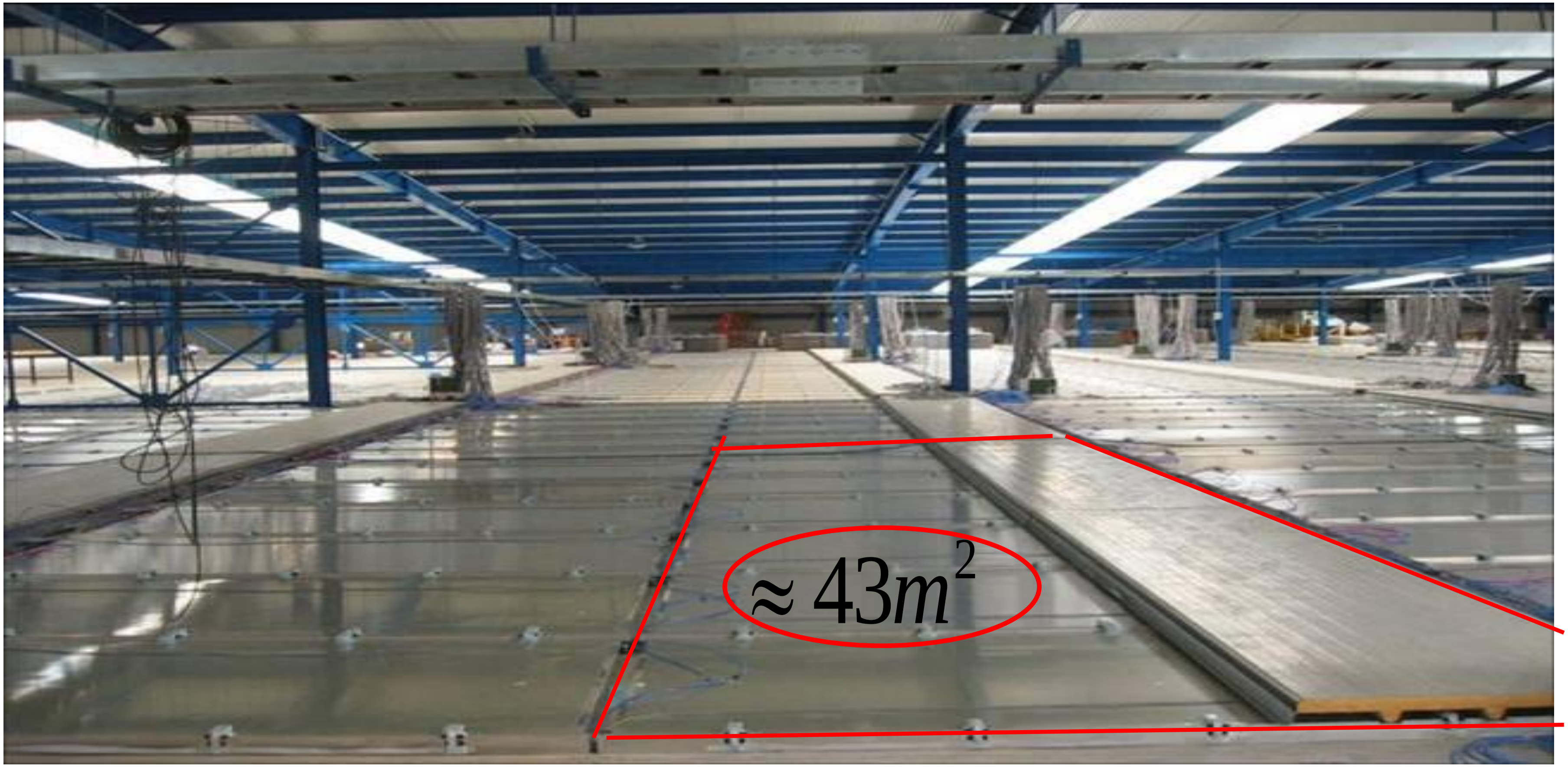
(*) See SURDO , this conference

two operational modes:

- **scaler mode**
  (register counting rates,
  no timing or spatial distribution
  of shower particles
  Energy threshold > 1 GeV)

- shower mode
  (full reconstruction, > 300 GeV)

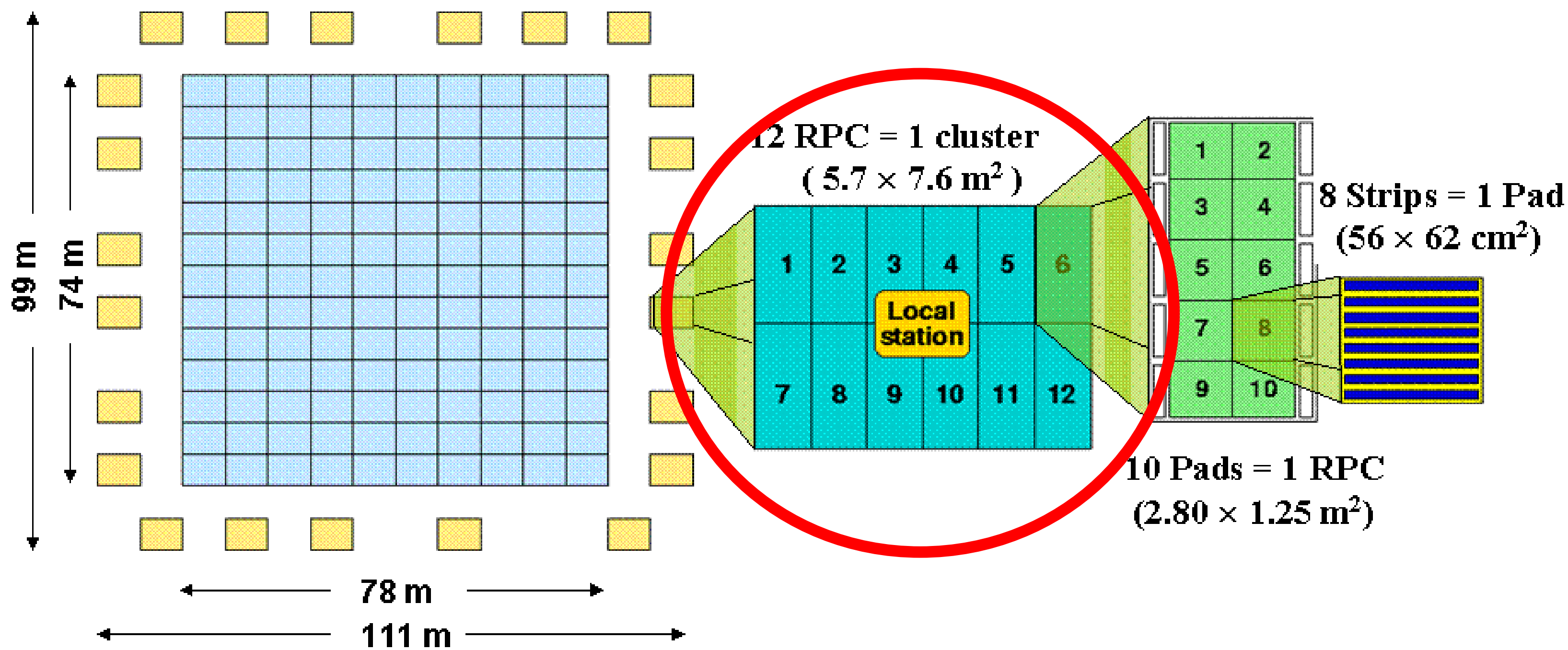
For what concerns us ……



With an energy threshold of few GeVs
It is possible to study

- flaring phenomena
  - ✓ high energy tail of GRBs,
  - ✓ solar flares,
  - ✓ Environment influence on shower development

….. the ARGO-YBJ detector is made of 153 counters ($43 m^2$ each) counting the number of "events" (coincidence150ns) with multiplicities >=1 ; >=2 ; >=3 ; >=4 in 0.5seconds … and rates 40KHz ; 2KHz ; 300Hz ; 120Hz .



counting rates are influenced by meteorological effects, mainly pressure and temperature variations.

ARGO-YBJ scaler mode with ≥1

Multiplicities	Barometric coefficients	Cosmic ray trigger rate
≥1	~0.4 %/mbar	~ 40 kHz
≥2		~ 2.1 kHz
≥3	~0.9 %/mbar	~ 310 Hz
≥4		~ 117 Hz

counting rates ≥2, ≥3 and ≥4 well reproduced by cosmic ray simulation at YBJ atm.depth,

the expectation value for ≥1 is sensibly lower

(*) G.Aielli et al., Astr.Phys.30(2008)85

In (**) , following a measurement of natural radioactive nuclei concentration in YBJ soil near the hall, it was suggested that the ***counting excess on the ≥1 counts coulld be due to*** **the high energy g emissions from the three natural radioactive series** (238U,232Th and 40K)

(**) C.Cattaneo , ICRC2009

RADON IN AIR :   POSSIBLE INFLUENCES ??

^{222}Rn and daughters

Nuclide	$T_{1/2}$	Principali energie (MeV) e abbondanze α	β_{max}	γ
$^{222}_{86}Rn$	3,82 d	5,49 (99,9%)	—	0,512 (0,078%)
$^{218}_{84}Po$	3,05 min	6,00 (100%)	0,256 (0,02%)	—
99,98% / 0,02%				
$^{214}_{82}Pb$	26,8 min	—	0,672 (46,6%) 0,729 (41,4%) 1,024 (8,5%)	0,242 (7,41%) 0,295 (18,7%) 0,352 (35,8%)
$^{218}_{85}At$	1,6 s	6,65 (6,4%) 6,69 (90,0%) 6,76 (3,6%)	2,89 (0,1%)	—
$^{214}_{82}Bi$	19,9 min	5,45 (0,012%) 5,51 (0,008%)	1,423 (8,38%) 1,505 (17,7%) 1,540 (17,6%)	0,609 (45,0%) 1,12 (14,9%) 1,76 (16,1%)
99,98% / 0,02%				
$^{214}_{84}Po$	165 µs	7,69 (100%)	—	0,800 (0,014%)
$^{210}_{81}Tl$	1,3 min	—	1,32 (~25%) 1,87 (~56%) 2,34 (~19%)	0,298 (76,0%) 0,800 (98,9%) 1,31 (21,0%)
$^{210}_{82}Pb$	22,2 a	3,72 ($2 \cdot 10^{-6}$%)	0,016 (80%) 0,063 (20%)	0,047 (4,06%)

Ref: Rapporti ITISAN 01/12, 2002

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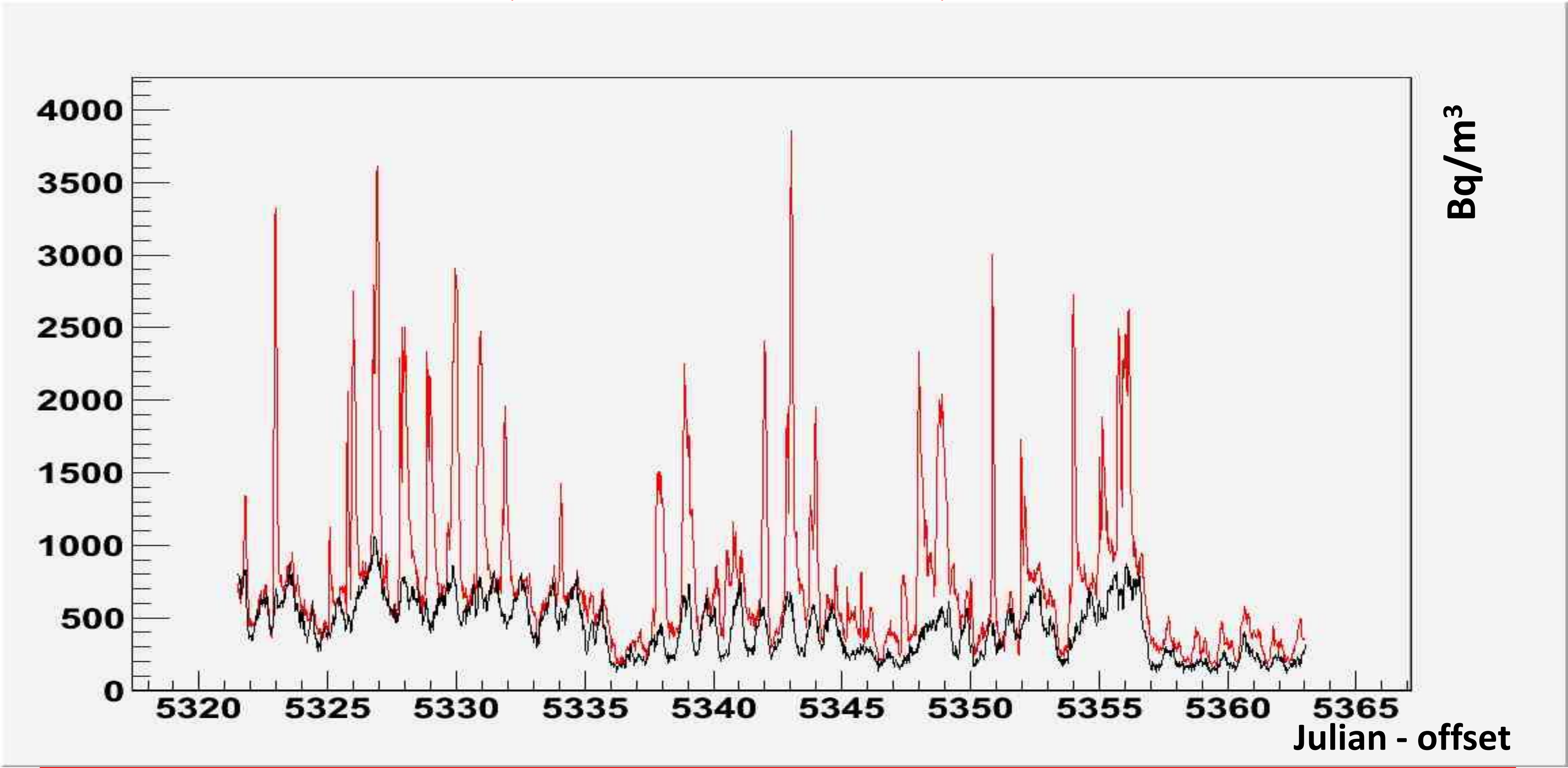
A time variable phenomenon we should take into account while correcting the scalers for the environmental parameters variation

Ref: Rapporti ITISAN 01/12, 2002

RADON MEASUREMENTS IN AIR (Lukas Cell)

30 days, May2010



Radon enters the Argo hall from soil and cracks ,mainly on the north side (impressive concentration!!!) and exit through doors and windows with an ease dependent on ventilation and atmopheric conditions

Montecarlo simulations in air

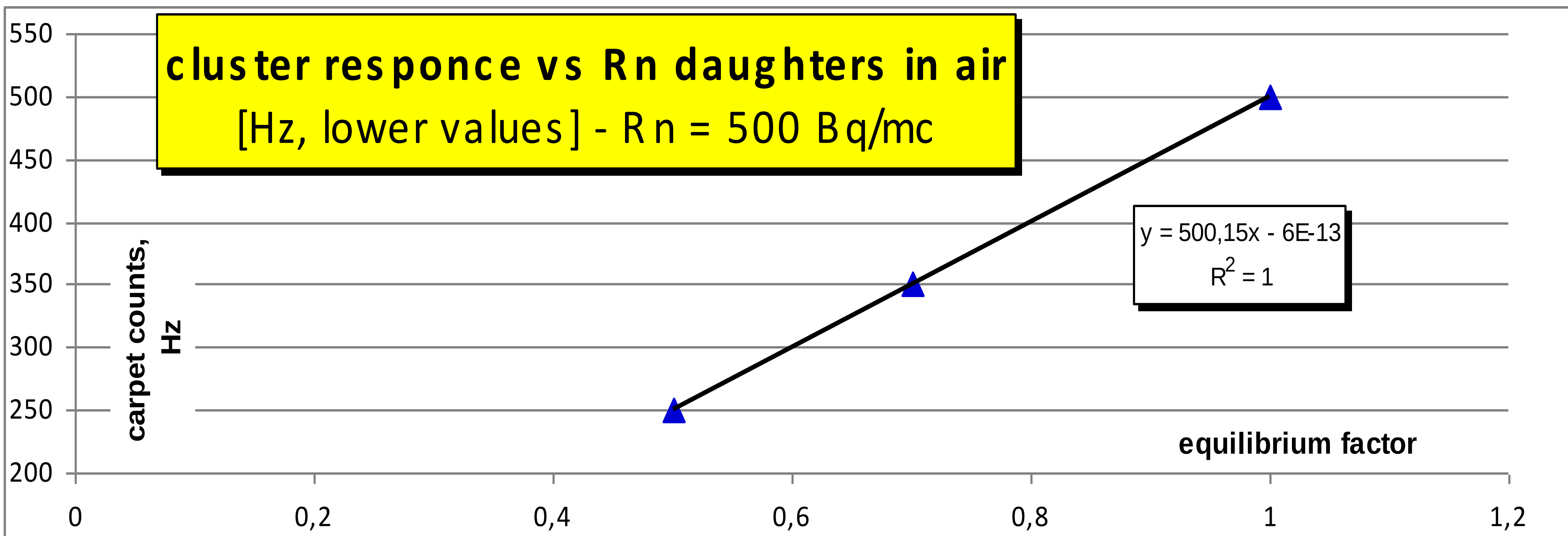
	Eγ (KeV)
Bi 214	609
	1120
	1238
	1764
Pb 214	87
	242
	295
	352
Pb 210	47
Pb 212	87
	239
	306
Tl 208	583
	860
	2615

Simulation with FLUKA
using graphics user interface (GUI) FLAIR.

Simulation of cluster response is in complete agreement with measured experimental RPC efficiencies : about 1% for Eγ about 1.2MeV (^{60}Co source) and 0.5% for Eγ of 0.66MeV (^{137}Cs source)

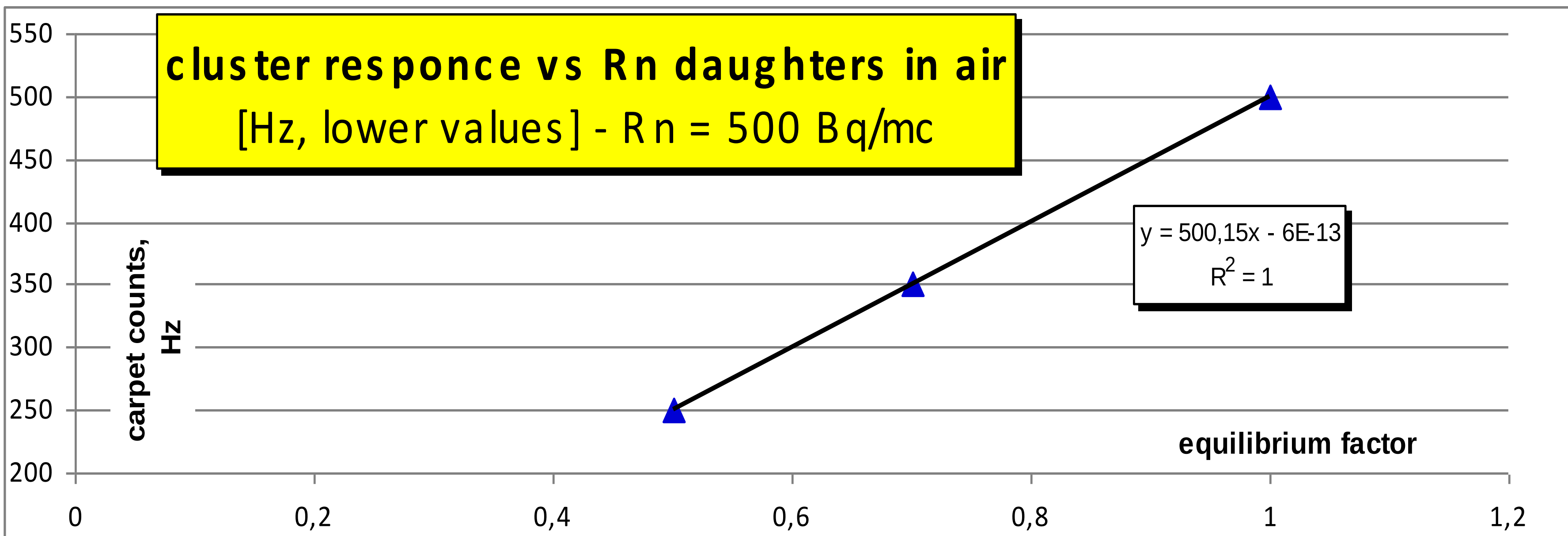
Montecarlo simulations in air

Rn conc., Bq/mc =	500	500	500
equilibrium factor =	1	0,5	0,7
CLUSTER RESPONCE vs Rn, Hz (lower value)			
H = 1 m	214	107	150
H = 2 m	398	199	278
H = 4 m	500	250	350
H = 0,003 m	0	628	377
H = 4,0003 m	500	878	727



Montecarlo simulations in air

Rn conc., Bq/mc =	500	500	500	1000	3000
equilibrium factor =	1	0,5	0,7	0,7	0,7
CLUSTER RESPONCE vs Rn, Hz (lower value)					
H = 1 m	214	107	150	299	897
H = 2 m	398	199	278	557	1670
H = 4 m	500	250	350	700	2101
H = 0,003 m	0	628	377	754	2261
H = 4,0003 m	500	878	727	1454	4361



Simulation results (Radon in air)

- Radon daughters γ emitters could influence on scaler C=1,

- The excess on the C=1 rate due to a 500 Bq/m3 of Radon
- concentration varies roughly from 300Hz to 1KHz

(depending mainly on the percentage of daughters still present in the air)

- That means an expected linear regression coefficient

$$\frac{\Delta C}{C_0} = \mu \ \Delta R$$

μ between 0.0015% and 0.005%

ΔC = counting rate for C=1 variation respect to the average C_0
ΔR = Radon concentration value variation respect to the average

RADON CONCENTRATION VARIATIONS

radon: **time variations**

In a stationary state, radon concentration could be written:

C_{Rn}= radon concentration, Bq/m3,

E_{Rn}= radon entering volume V, Bq/sec,

λ_{Rn} = radon decay constant , 2,1·10^{-6} */sec*

I_{vent}= ventilation, in (air exchange/sec.)

OUT

$$\frac{dC_{Rn}}{dt} = \frac{E_{Rn}}{V} - (\lambda_{Rn} + I_{vent})C_{Rn}$$

IN

Complex time variations in a open building with ventilation conditions varying during the day

Ref: NCRP 103, 1989

RADON IN AIR : POSSIBLE INFLUENCES ??

- Single countings affected by daughters, not directly by the Rn
- Secular equilibrium reached after hours (but meanwhile radon daughters are removed from the hall by ventilation)
- Probably dependence of C=1 rate is on radon measured at the hall center (averaged behaviour) instead of the instant value measured at the north side

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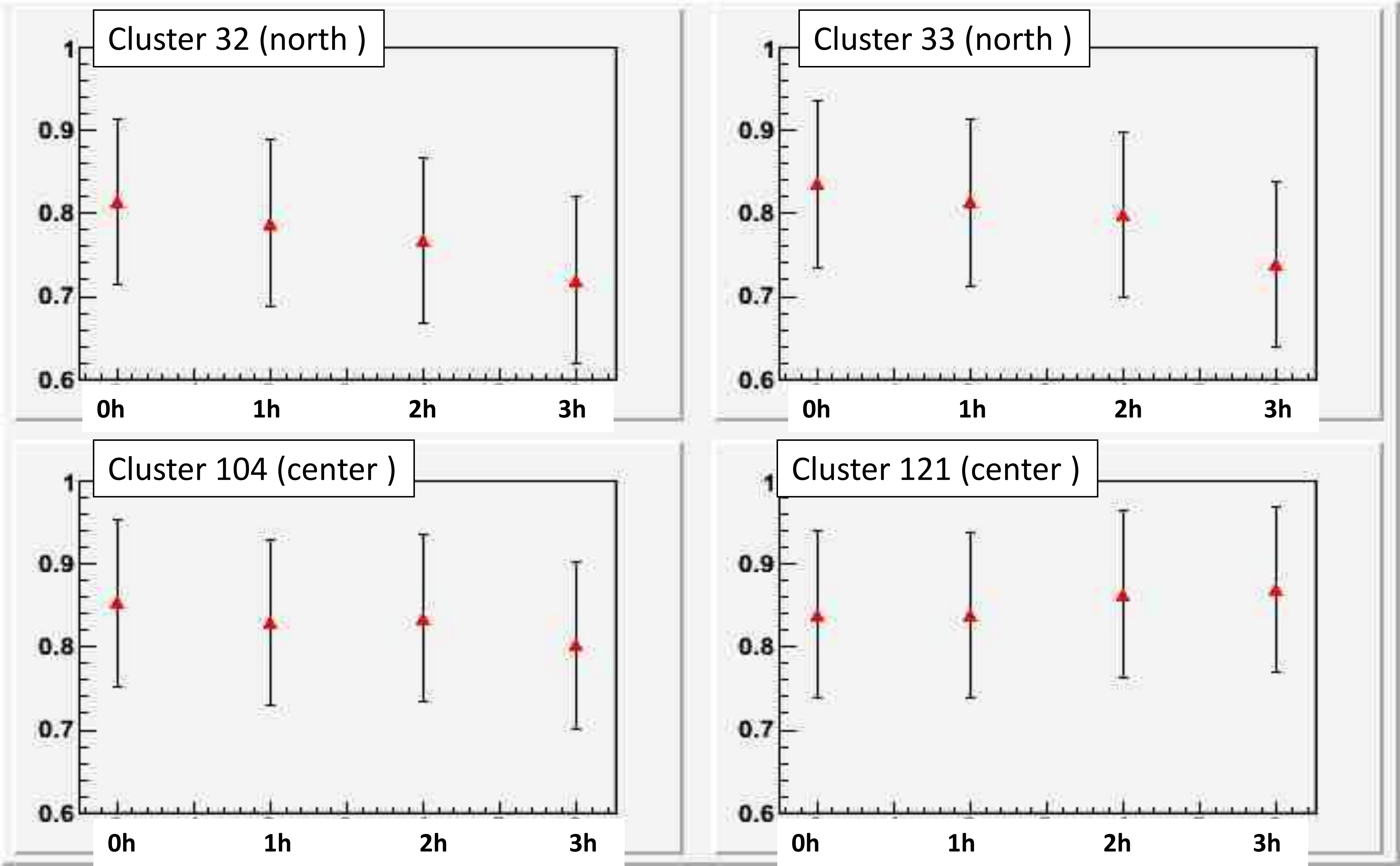
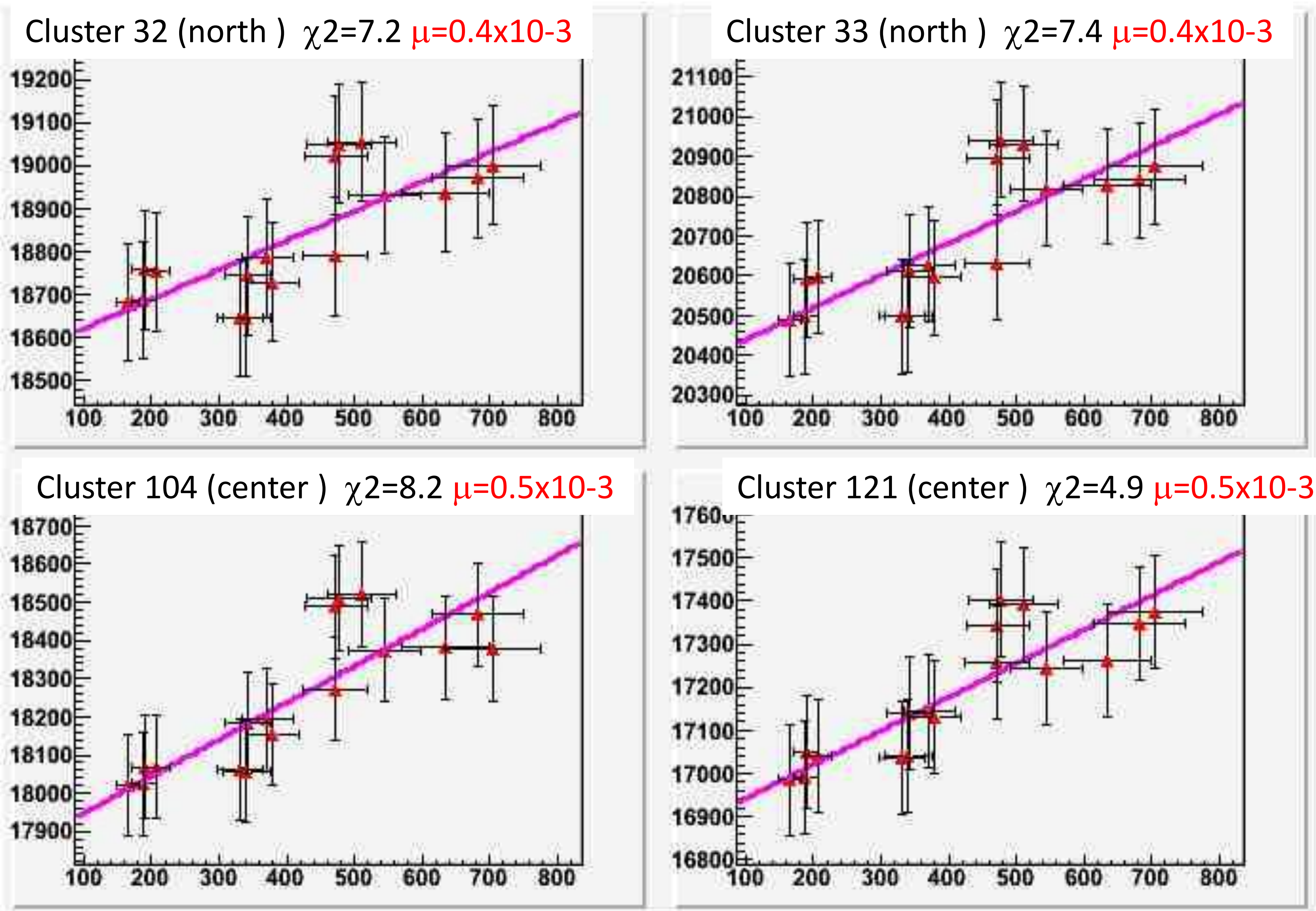
↓

- Look for correlation in data in the same pressure range (ΔP=0.4mbar) and same temperature (ΔT=0.5°)

Correlation factors (C=1 vs. Daughter's Delay)



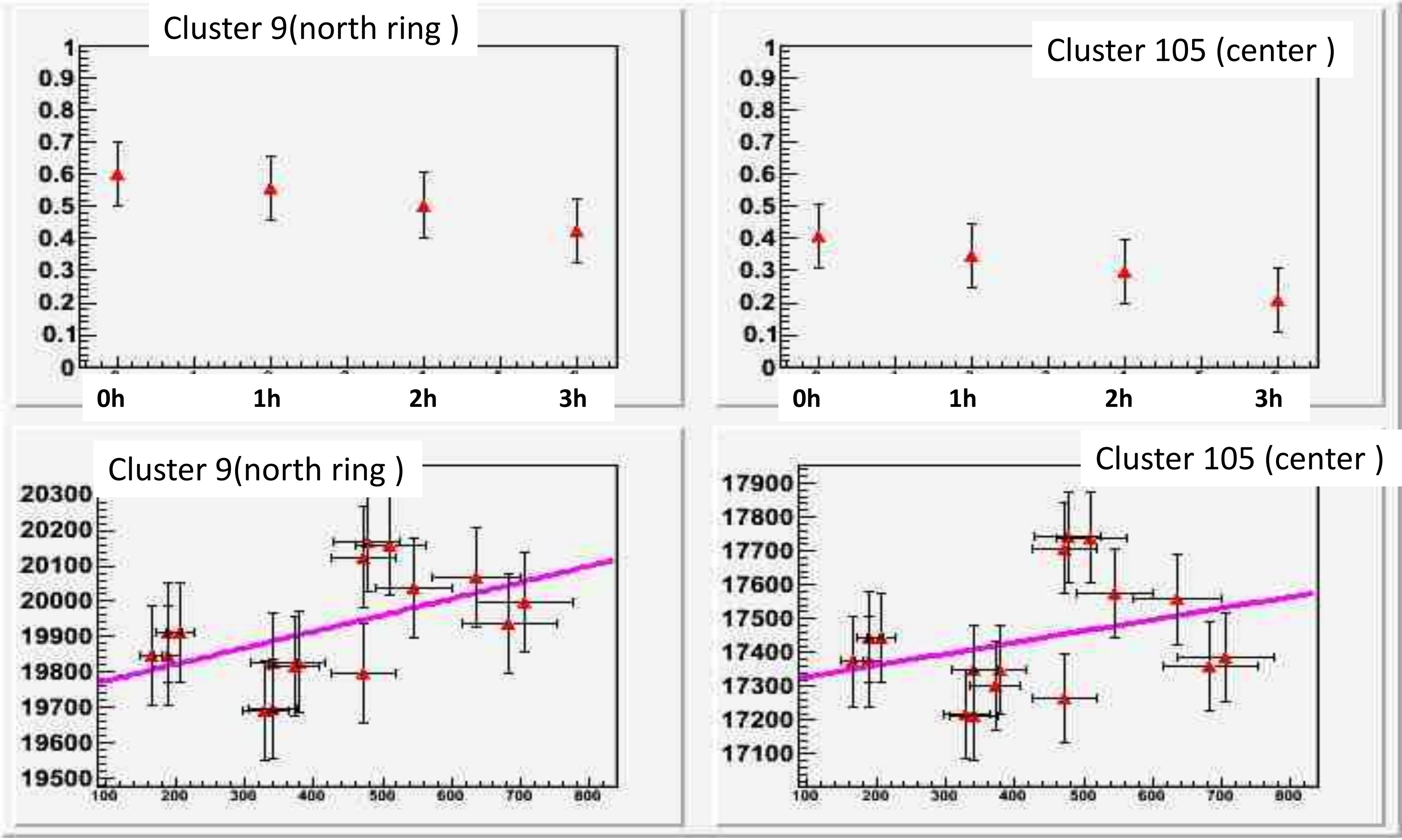
C=1 vs. Radon@carpet center



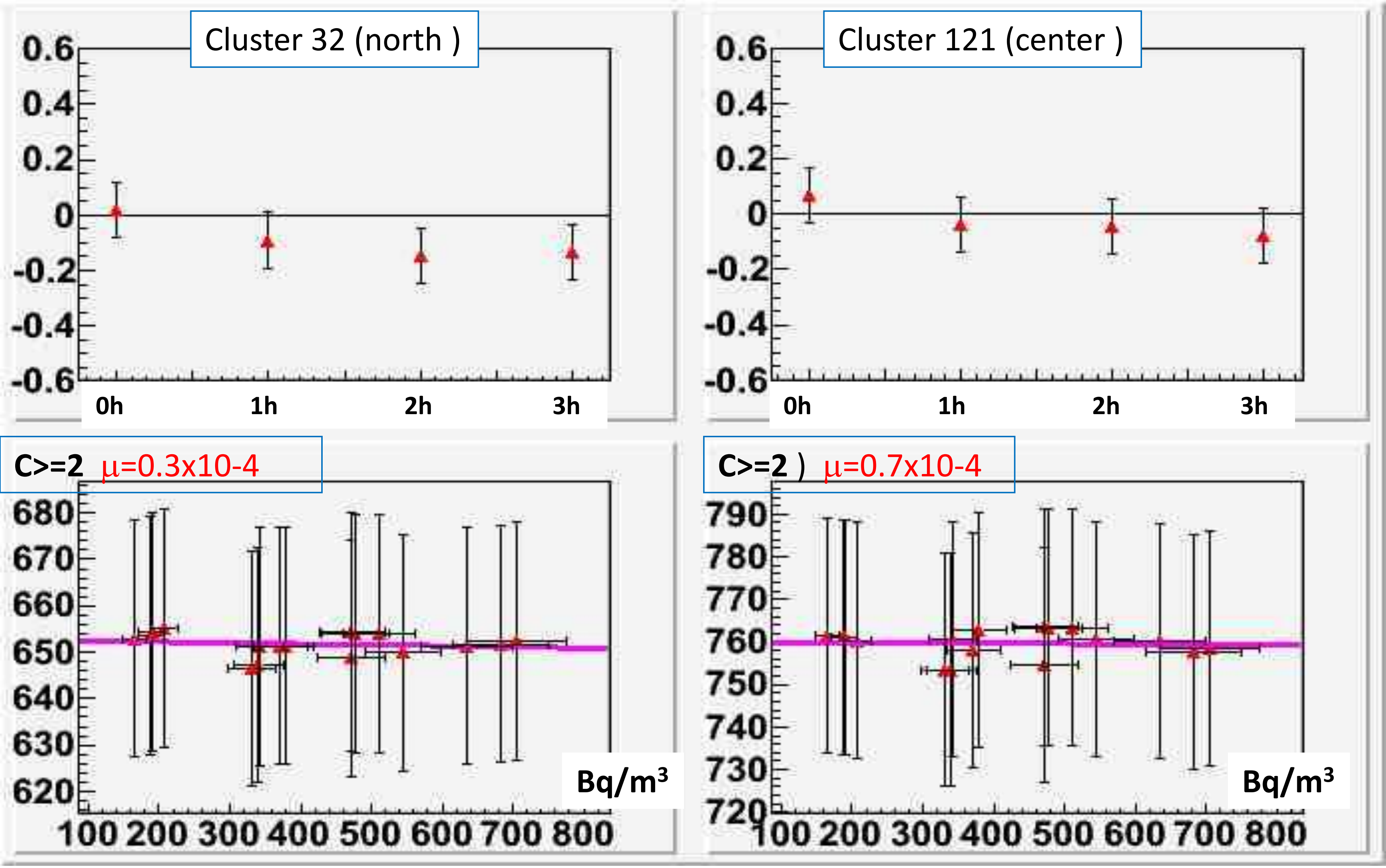
Comments ……

- Correlation independent from time delay between Rn concentration and counting excess
  (cancelled by new radon emission or ventilation)
- Correlation with Radon at center is generally better respect to measure at North (it represents a good average concentration)
- Not all clusters on carpet show the same correlation…
  15- 20% appear to be badly to nothing correlated
  (spatial Rn distribution or locally different temperature?)
- What happens to multiplicity >=2 ??

Correlation factors (C=1 vs. Delay) (ANOMALOUS CLUSTERS)



Correlation factors (C>=2 vs. Daughter's Delay)



Summary:

- Radon daughters in air influence the C=1 Argo counting rate

- the simulated regression coefficient is consistent with the one experimentally observed

- Dependency is on the "averaged" concentration values, due to the intrinsic variability of radon emission and of ventilation building conditions

Diapositive di scorta

Measurements in place

1. **H*(10) rates (ambient equivalent dose):** different conditions and places; with AT1123A, plastic scintillator, photon energy range: 60 keV - 10 MeV

2. **gamma ray spectra** in different places, at soil/floor level, to quantify disomogeneities; NaI(Tl) detector (low resolution, but with best handleing ability - NO shield: in this condition it detects both soil and environmental gamma radiations - there wasn't radioactive source for calibration)

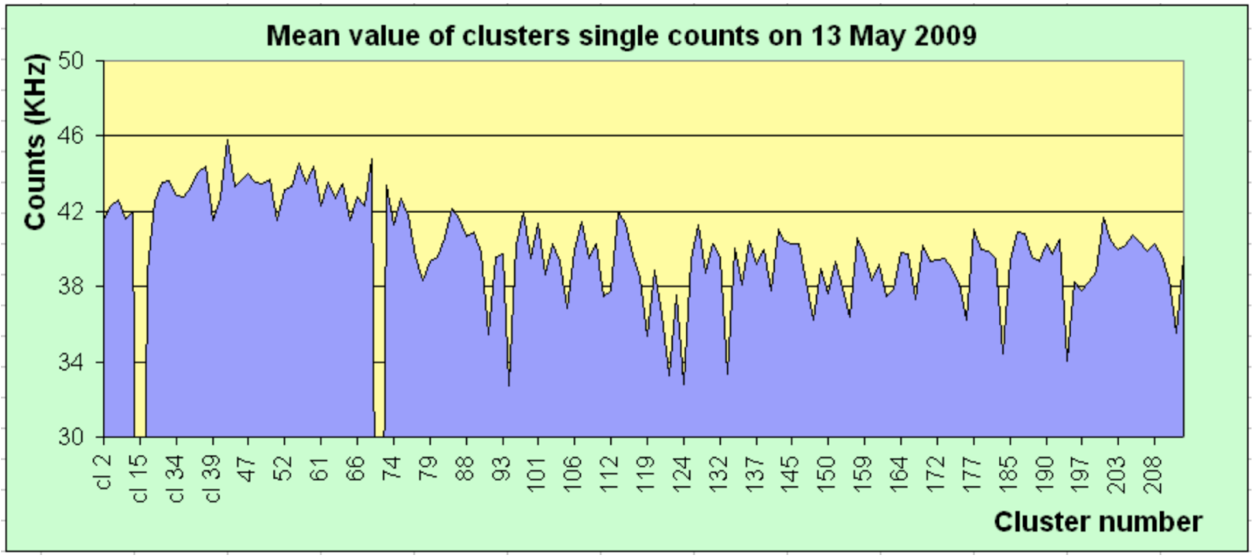
3. **Rn gas time variations** in air (different places and long periods) - MR1 system, **lukas cell apparatus**: the system has to be normalised at ARGO ambient pressure, 550-600 mbar)

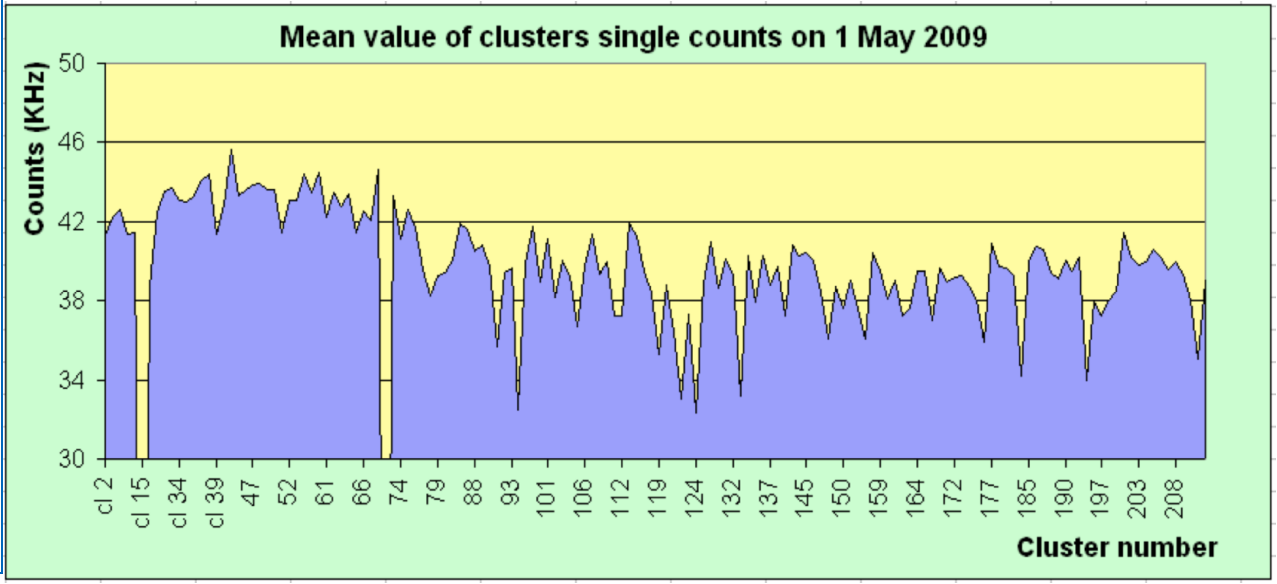
4. **CR-39 passive detectors:** measure the average Rn spatial homegeneity over the ARGO carpet (40 dosemeters)

5. **soil samples** analysed in Pavia (HPGe spectra) – 4 samples

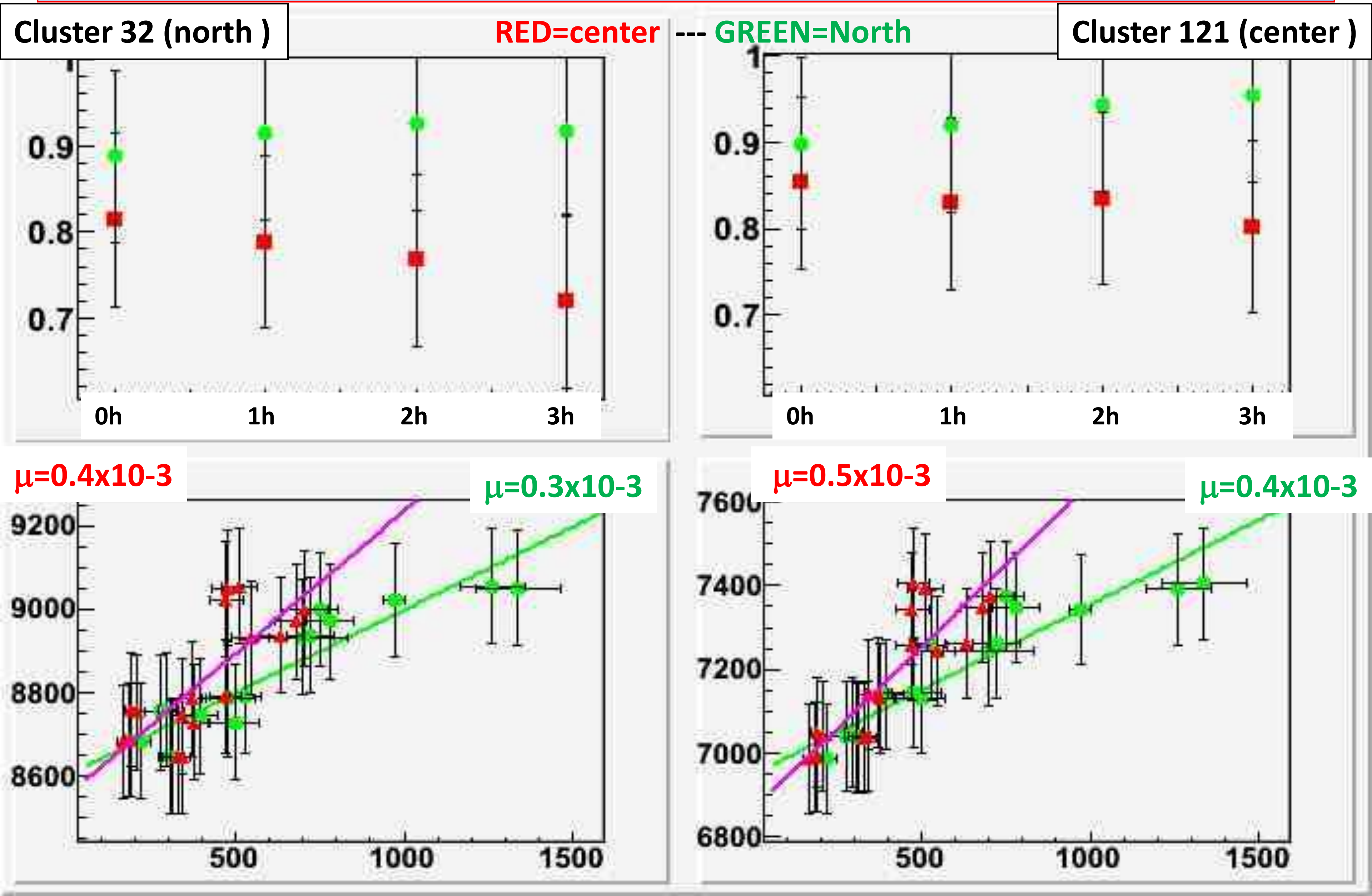
Clusters C>=1 counts

1. H*(10) appears quite spatially omogeneus over different areas of ARGO carpet
2. **H*(10) rate is higher in the North side than in the South side, *according with ARGO counting***
3. H*(10) rate is greater at Argo installation than at sea level
4. H*(10) measured is referred to gamma radiation of "low" energy (<10 MeV)



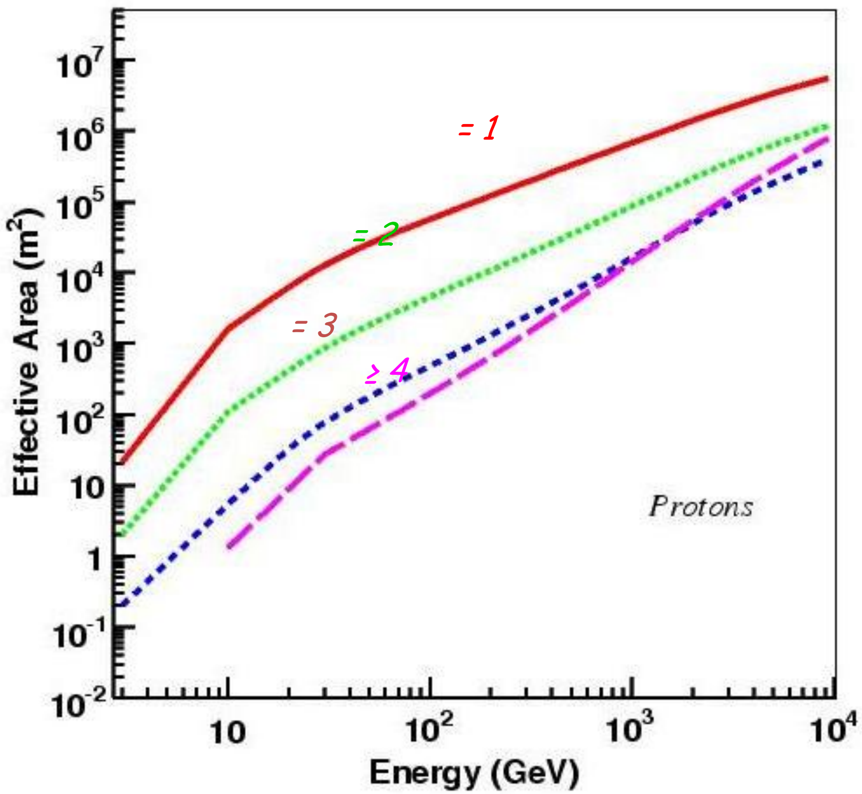


Corr.Factor C=1 vs. Daughter’s Delay & C=1 vs.Radon

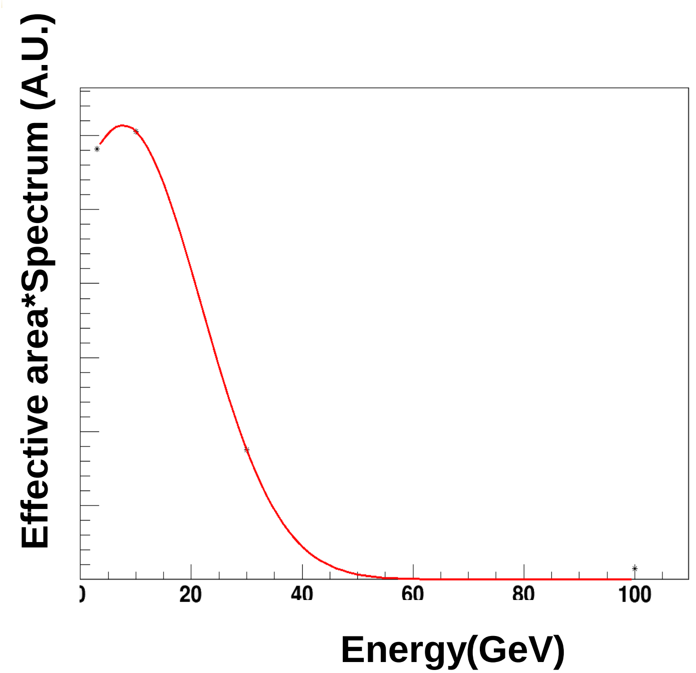


What can we do with ARGO-YBJ?

Folding of the proton effective area (N=1) with the mean spectral index of solar flares:



$$d\phi = AE^{-\alpha}dE \qquad \alpha = 3.22$$



C=1 CORRISPONDS TO MAX SENSITIVITY AT MINIMUM ENERGY!!!!

Montecarlo simulations in air

	Eγ (KeV)
Bi 214	609
	1120
	1238
	1764
Pb 214	87
	242
	295
	352
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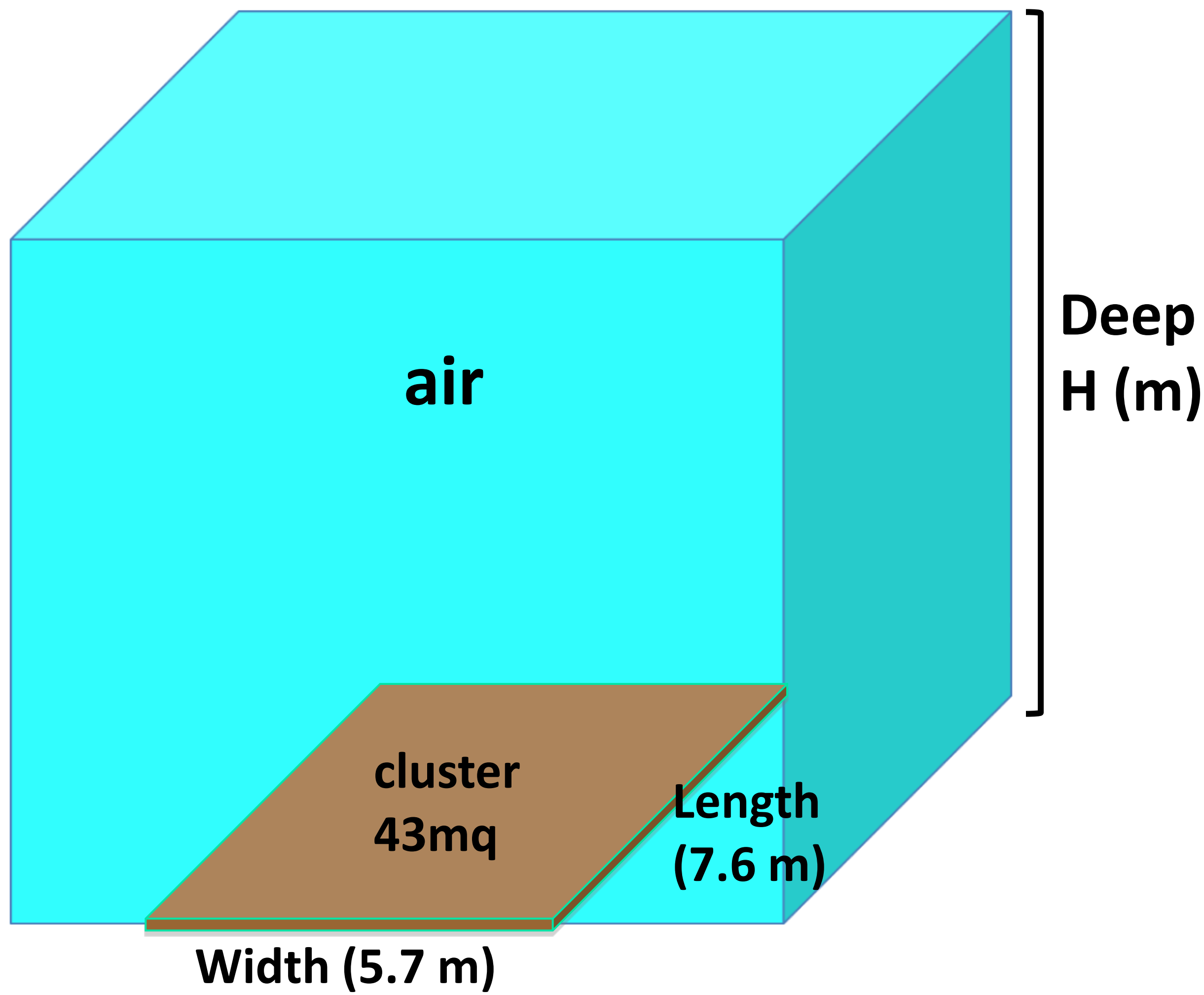
Simulation with FLUKA

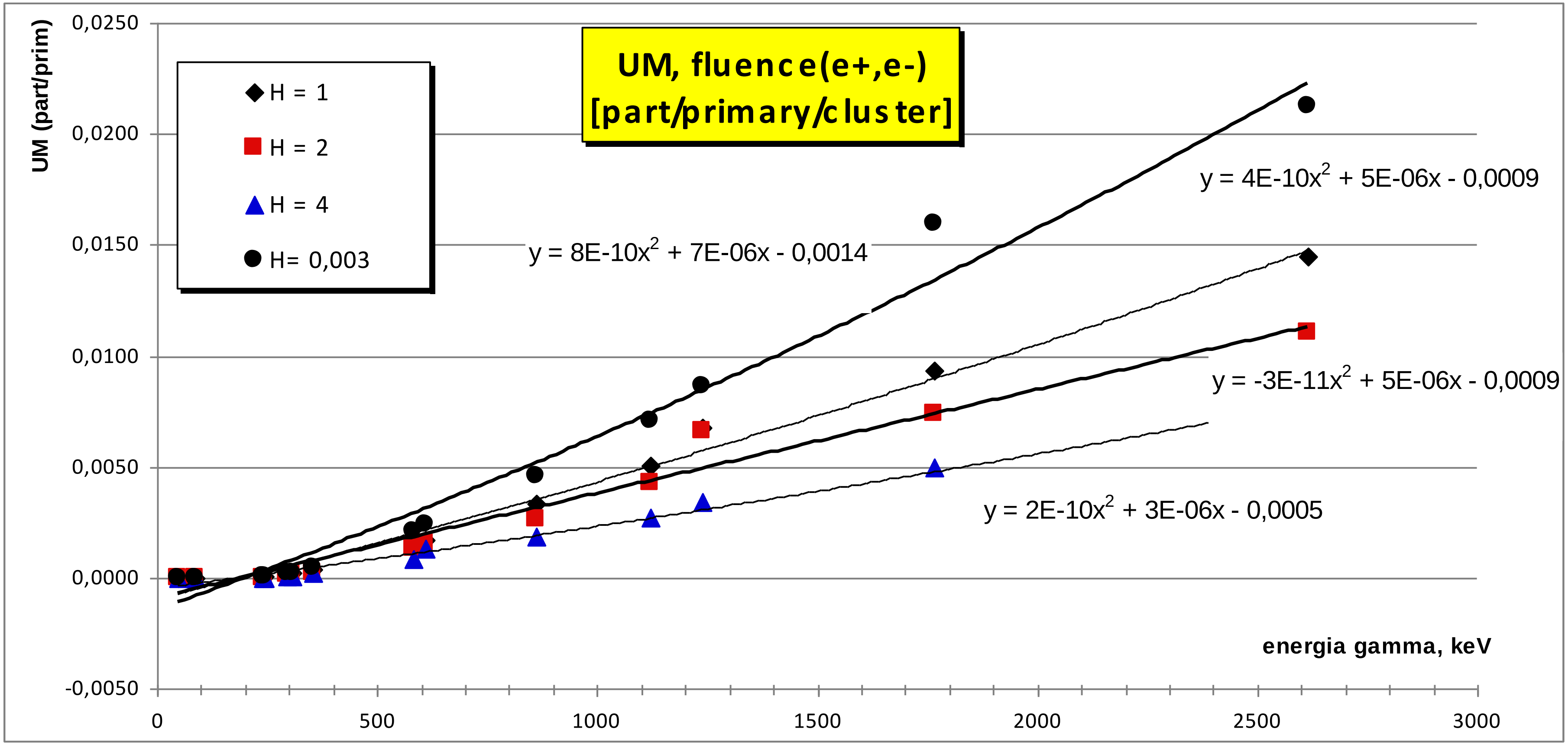
using graphics user interface (GUI) FLAIR.



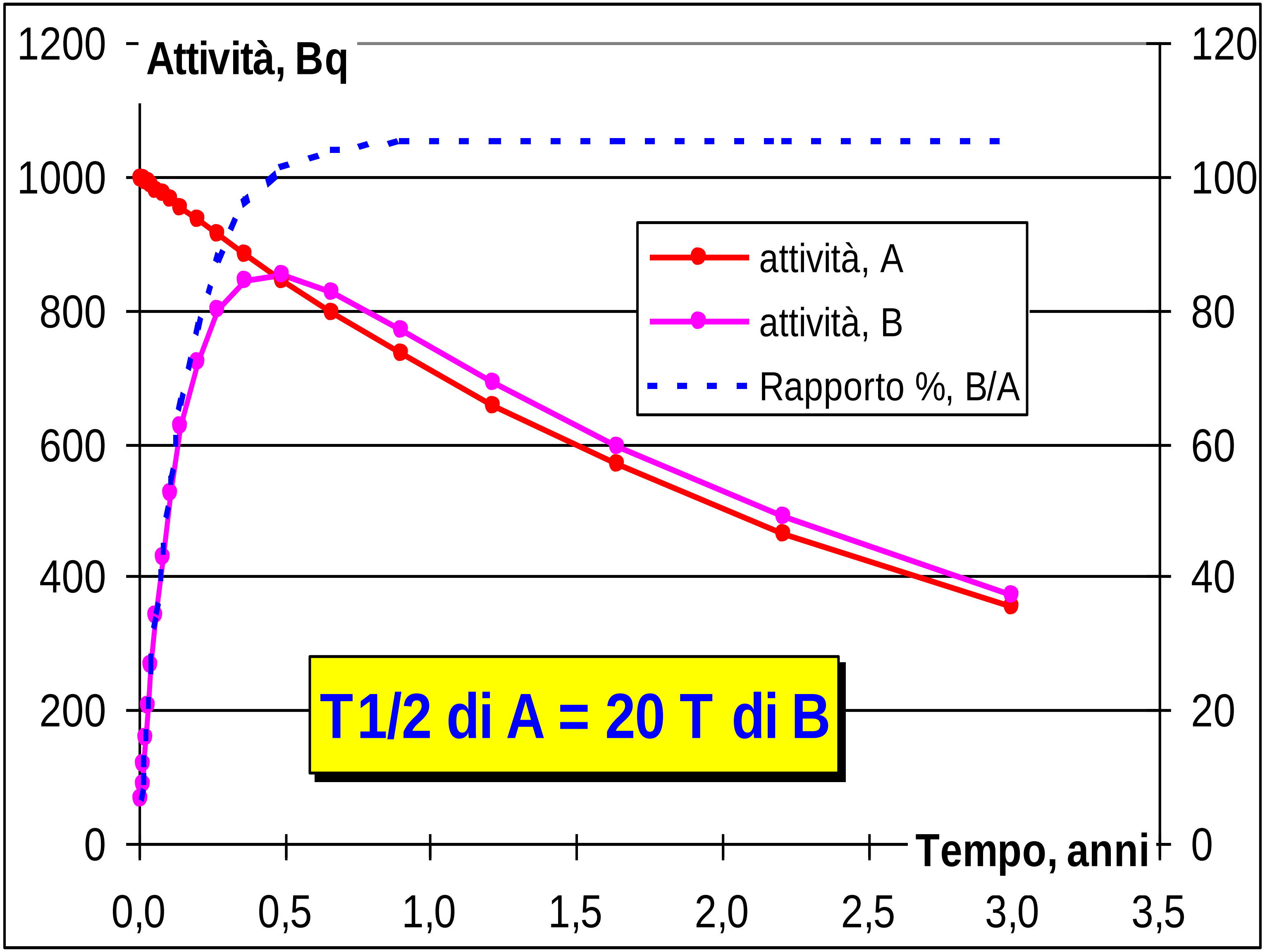
Montecarlo simulations in air

Complete agreement with measured experimental RPC efficiencies : about 1% for Eγ about 1.2MeV (^{60}Co source) and 0.5% for Eγ of 0.66MeV (^{137}Cs source)

Geometric efficiencies (different colours) vs Gamma ray energy

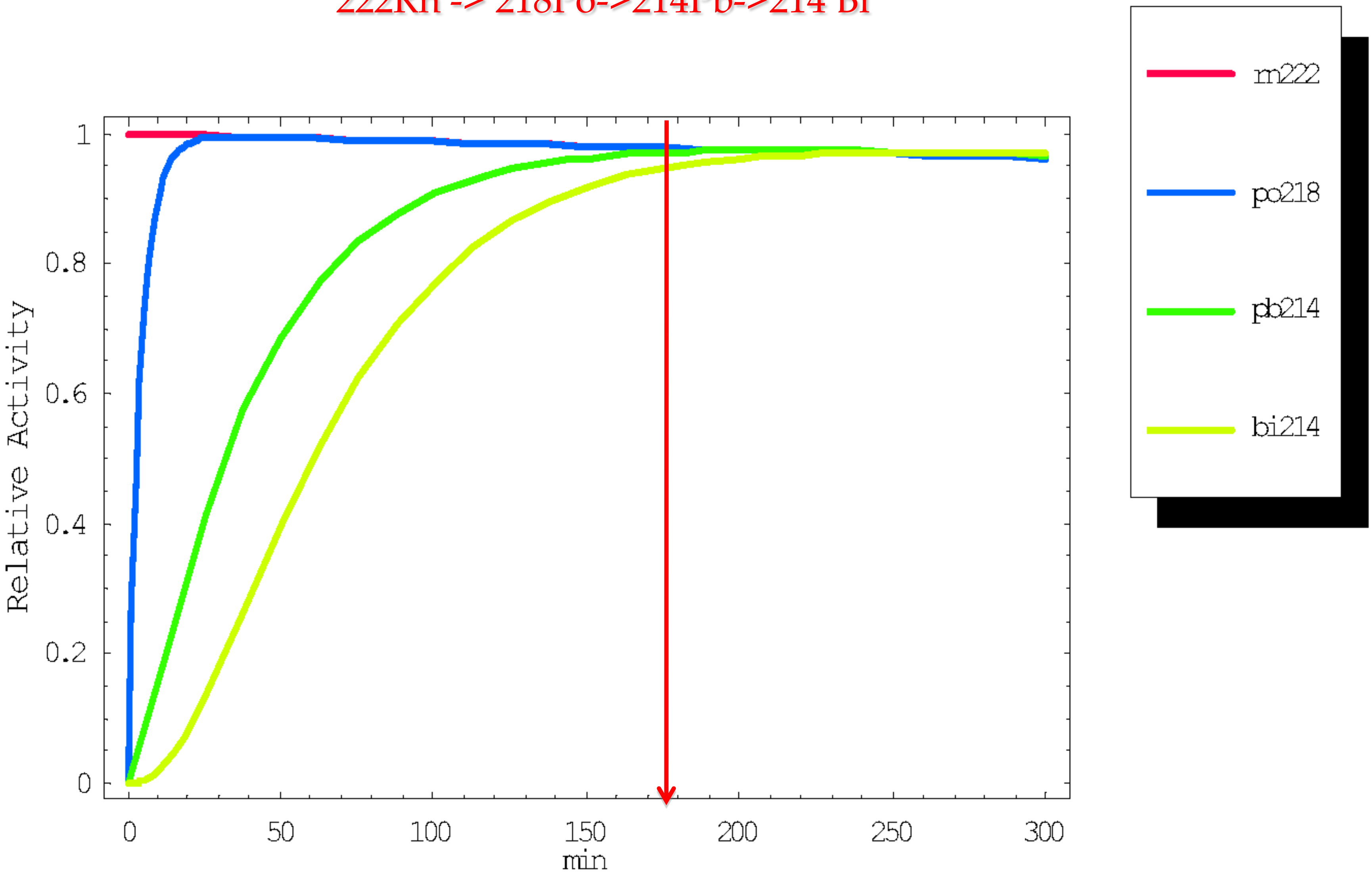


famiglie radioattive
equilibrio secolare



$\lambda_A << \lambda_B$ $T_{1/2}(A) >> T_{1/2}(B)$ $Att_B(t) = Att_A(t)$

That's the case for
222Rn -> 218Po->214Pb->214 Bi



~ 3 h are needed to get the equilibrium

famiglie radioattive
equilibrio secolare

$$A \rightarrow B \rightarrow C$$

$$N_B(t) = \frac{\lambda_A}{\lambda_B - \lambda_A} \cdot N_A(t)$$

$$\lambda_A << \lambda_B$$

$$\lambda_B - \lambda_A \cong \lambda_B$$

$$\lambda\, N(t) = Att(t)$$

$$Att_B(t) = Att_A(t)$$

Se il tempo di dimezzamento del padre è molto maggiore di quello del figlio, allora l'attività del discendente è uguale a quella del progenitore (l'attività e non il numero di atomi radioattivi!)

Measures in place, H(10)*

H*(10) RATE GENERAL STATISTICS	values, n.	AVERAGE	1 ST.DEV	ST.D, %
ARGO - Guest House - room SN 5	7	0,45	0,01	3,0
ARGO carpet - cluster 031	9	0,39	0,02	3,9
ARGO carpet - cluster 035 - 036	5	0,39	0,03	6,5
ARGO carpet - cluster 040	14	0,39	0,02	5,4
ARGO carpet - cluster 115	4	0,35	0,00	1,4
ARGO carpet - cluster 124	8	0,34	0,01	4,2
ARGO carpet - cluster 199	9	0,34	0,03	7,8
ARGO carpet - cluster 205	11	0,35	0,02	5,4
ARGO carpet - cluster 208	18	0,33	0,02	6,8
ARGO carpet - DCS location	10	0,33	0,08	23,9
EG's home - garden	2	0,11	0,00	4,6
Lhasa - Post Hotel - 2nd floor	4	0,23	0,01	2,8
General statistics	101	0,35	0,06	17,6

1. H*(10) appears quite spatially omogeneus over different areas of ARGO carpet
2. H*(10) rate is higher in the rear side than in the front side, ***according with ARGO counting (Liguori preliminary data)***
3. H*(10) rate is greater at Argo installation than at sea level
4. H*(10) measured is referred to gamma radiation of "low" energy (<10 MeV)

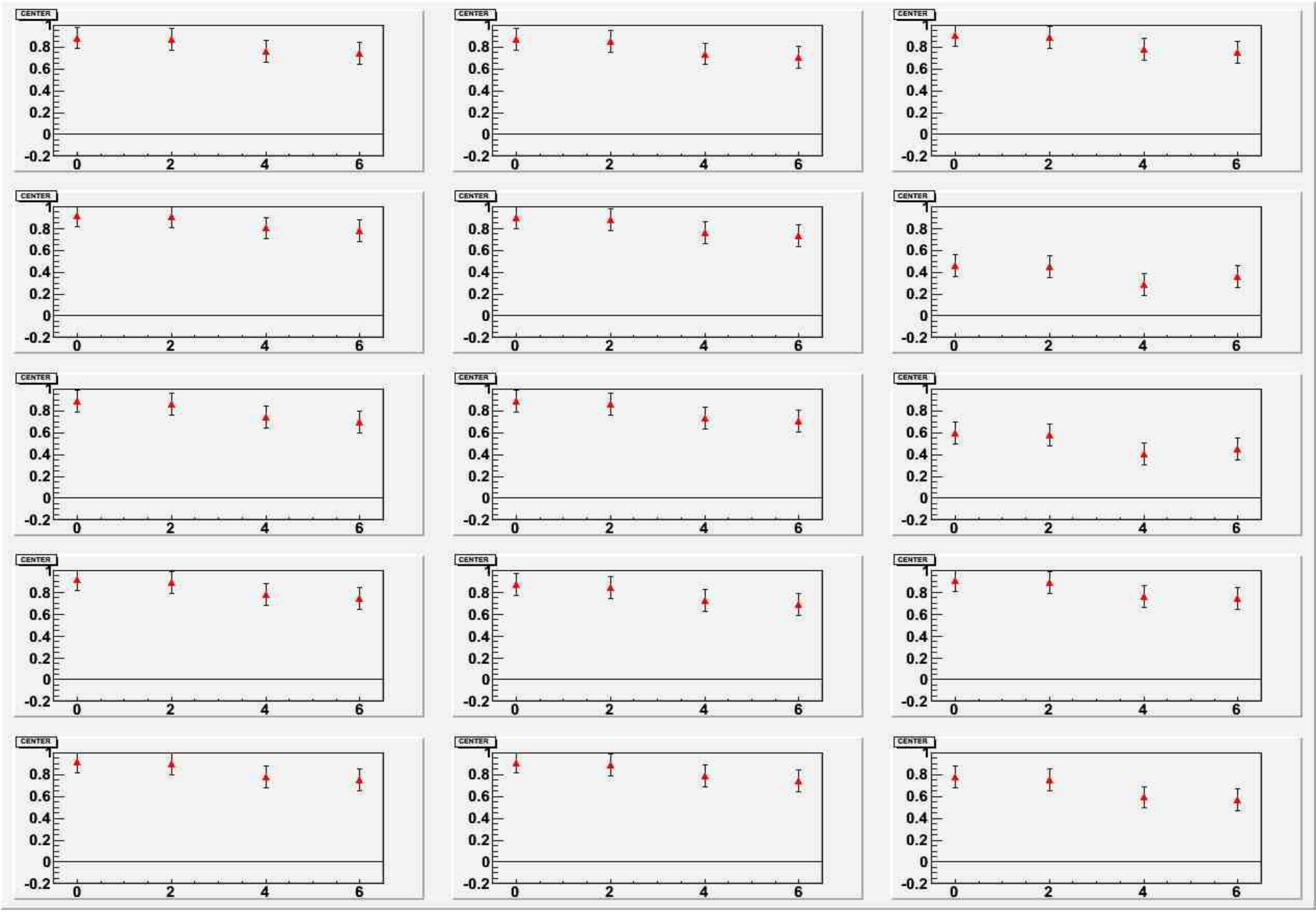
Montecarlo simulations in air

Rn concentration, Bq/mc =	500
Rn equilibrium factor =	0,5

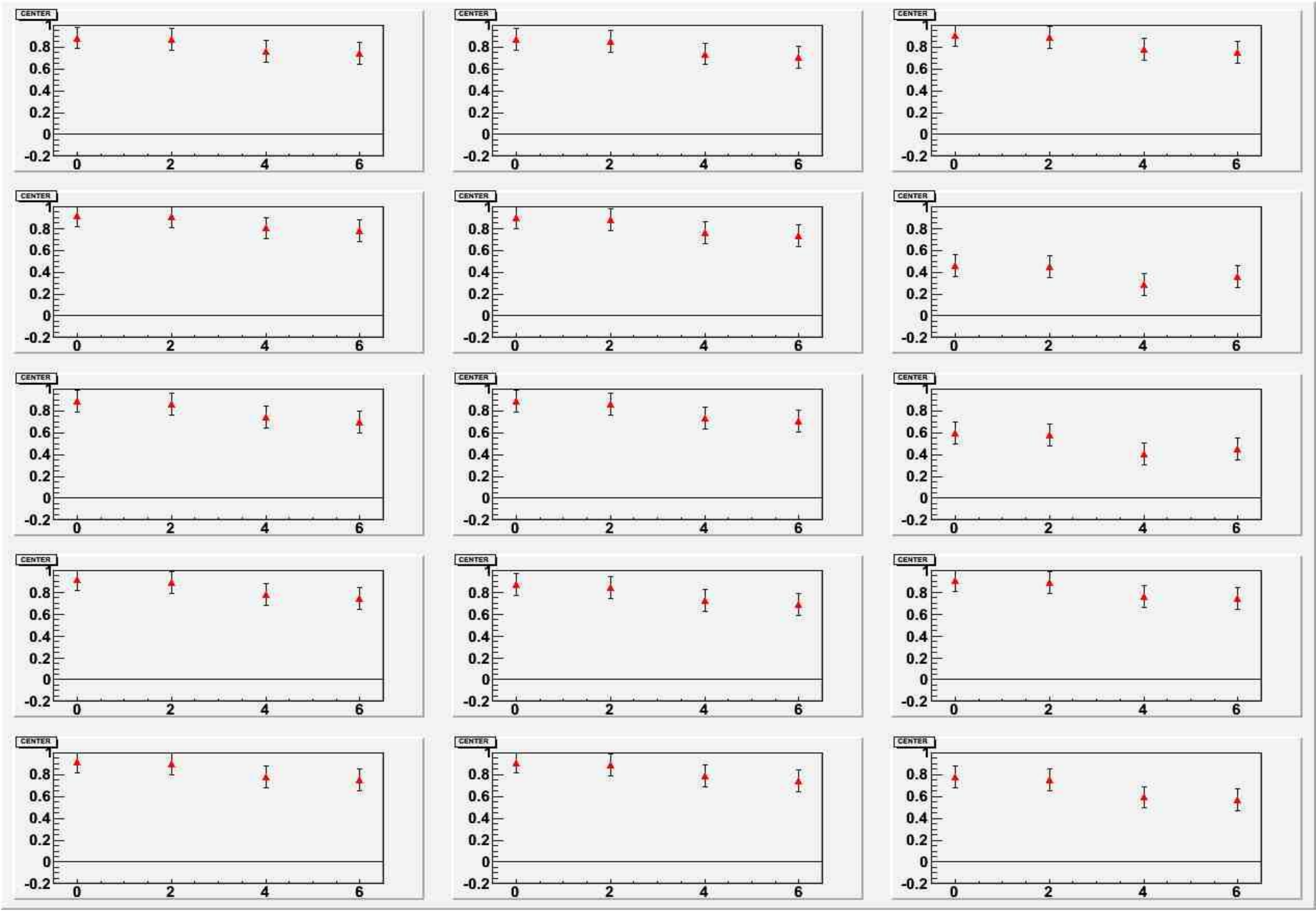
simulated VOLume Deep, H =	**1**	**2**	**4**	**0,003**	**4+0,003**
Volume of VOLume, mc =	**43**	**87**	**174**	**6.400**	6.400
VOL Rn activity, Bq =	**21.734**	**43.469**	**86.938**	**3.200.000**	3.200.000
VOL Rn daughter activity, Bq =	**10.867**	**21.734**	**43.469**	**43.469**	==

radionuclide	energy, E, keV	BR, %	**RESUME TABLE** cluster counts detected by RPCs because of Rn, Hz				
Bi-214 (*)	609,3	45,5	20	39	48	118	165
	665,5	1,5	1	1	2	4	6
	768,4	4,9	3	5	6	15	22
	934,1	3,1	2	4	5	12	16
	806,2	1,3	1	1	2	4	6
	1120,3	14,9	11	21	27	66	93
	1155,2	1,6	1	2	3	7	10
	1238,1	5,8	5	9	11	28	40
	1281,0	1,4	1	2	3	7	10
	1377,7	4,0	4	7	9	22	30
	1401,5	1,3	1	2	3	7	10
	1408,0	2,4	2	4	5	13	19
	1509,2	2,1	2	4	5	13	18
	1729,6	2,8	3	6	8	19	27
	1764,5	15,3	18	33	43	108	151
	1847,4	2,0	3	5	6	15	21
	2118,6	1,2	2	3	4	10	14
	2204,2	4,9	7	13	17	44	61
	2447,9	1,6	3	4	6	16	22
Pb-214 (*)	83	21,22	0	0	0	0	0
	242,0	7,3	0	0	0	0	0
	295,2	18,4	5	10	11	28	40
	351,9	35,6	10	21	24	61	86
	786,0	1,064	1	1	1	3	5
Pb-210 (*)	46,5	4,25	0	0	0	0	0
Pb-212 (*)	83	36,59	0	0	0	0	0
	238,6	43,6	0	0	0	0	0
	300,6	3,18	1	2	2	5	7
TOTAL			**107**	**199**	**250**	**628**	**878**

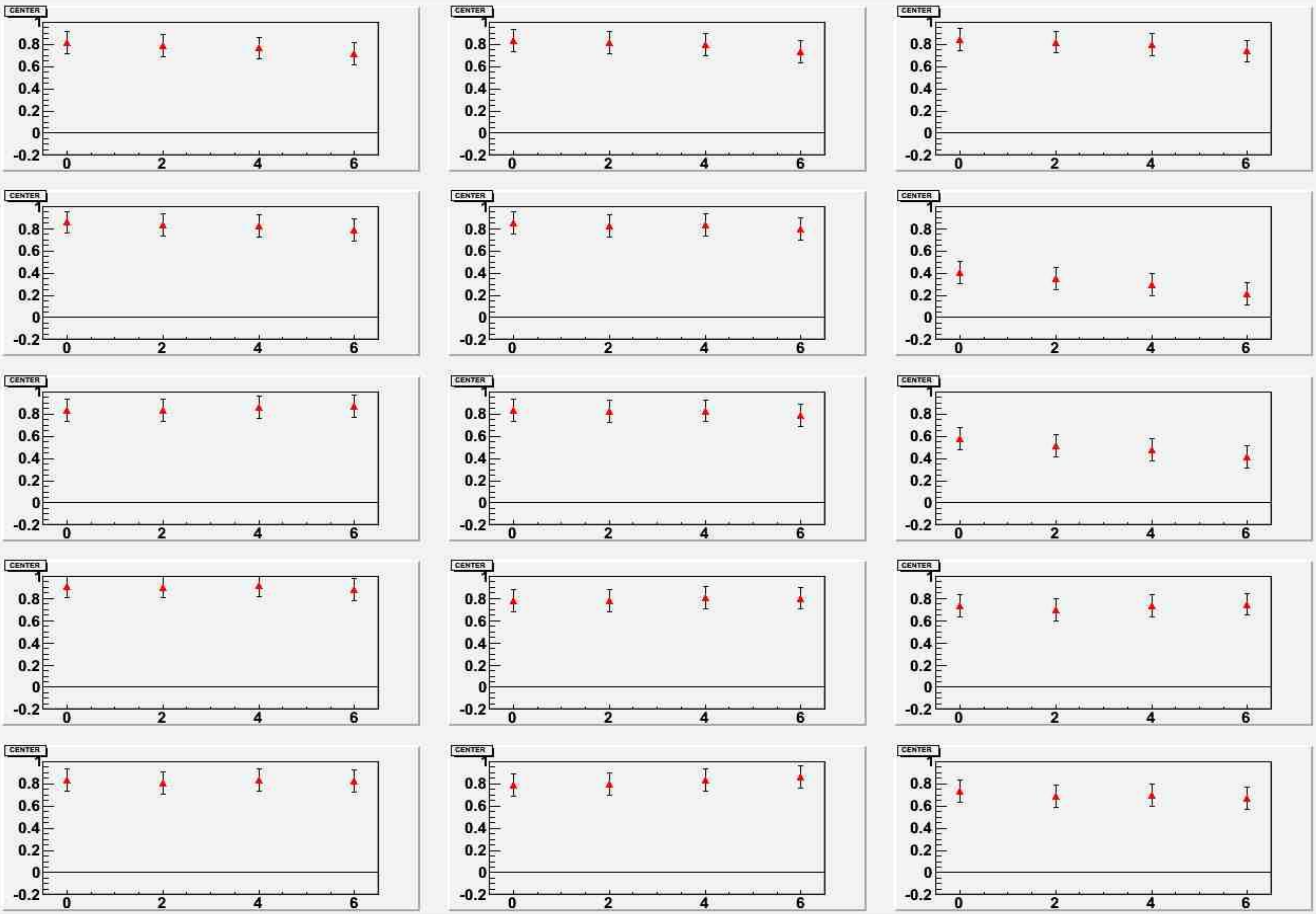
Correlation factor vs.Delay - Radometer@carpet center – Press. cut 600mbar – Yscale -0.2->1.



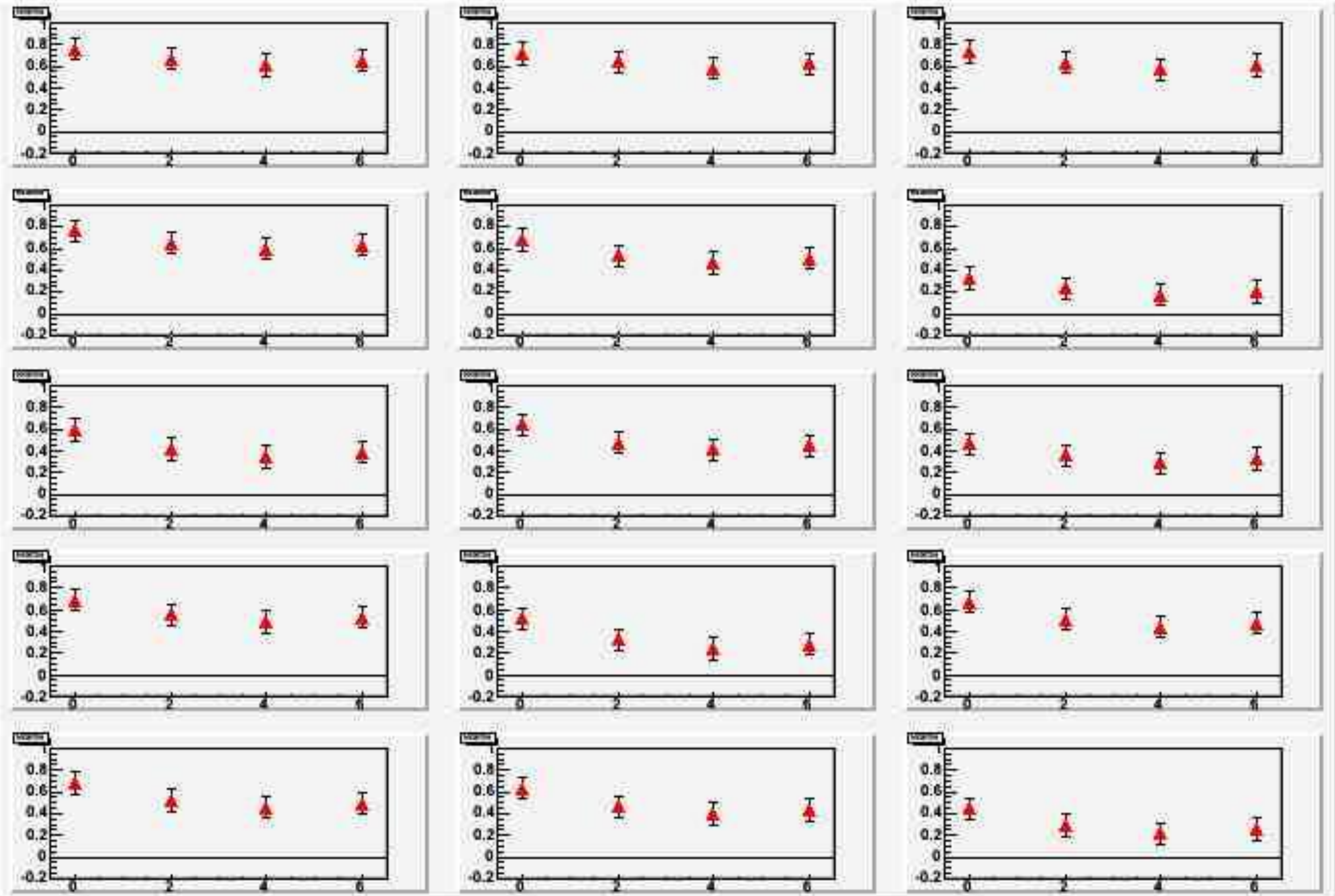
Correlation factor vs.Delay - Radometer@carpet center – Press. cut 601mbar – Yscale -0.2->1.



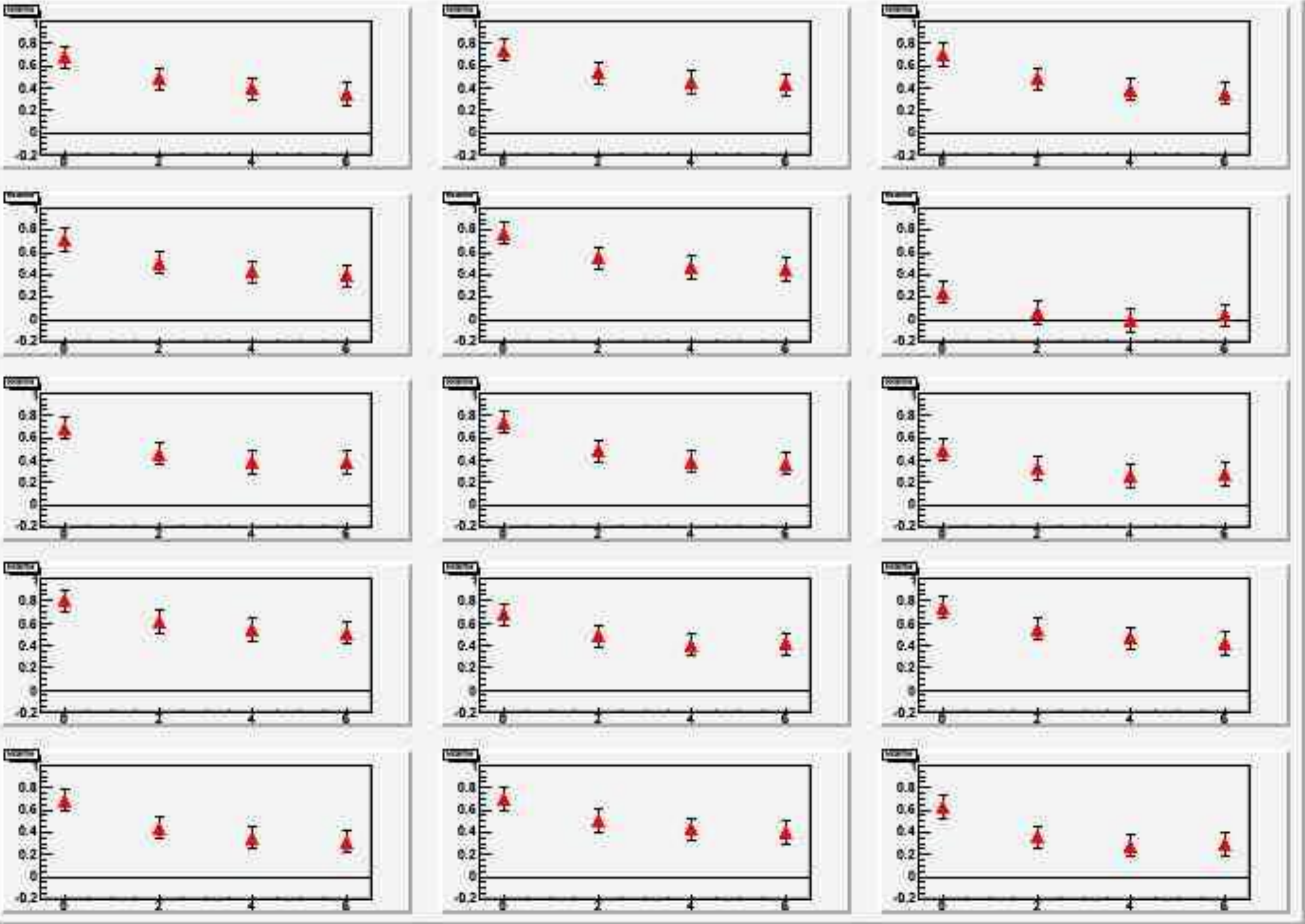
Correlation factor vs.Delay - Radometer@carpet center – Press. cut 602mbar – Yscale -0.2->1.



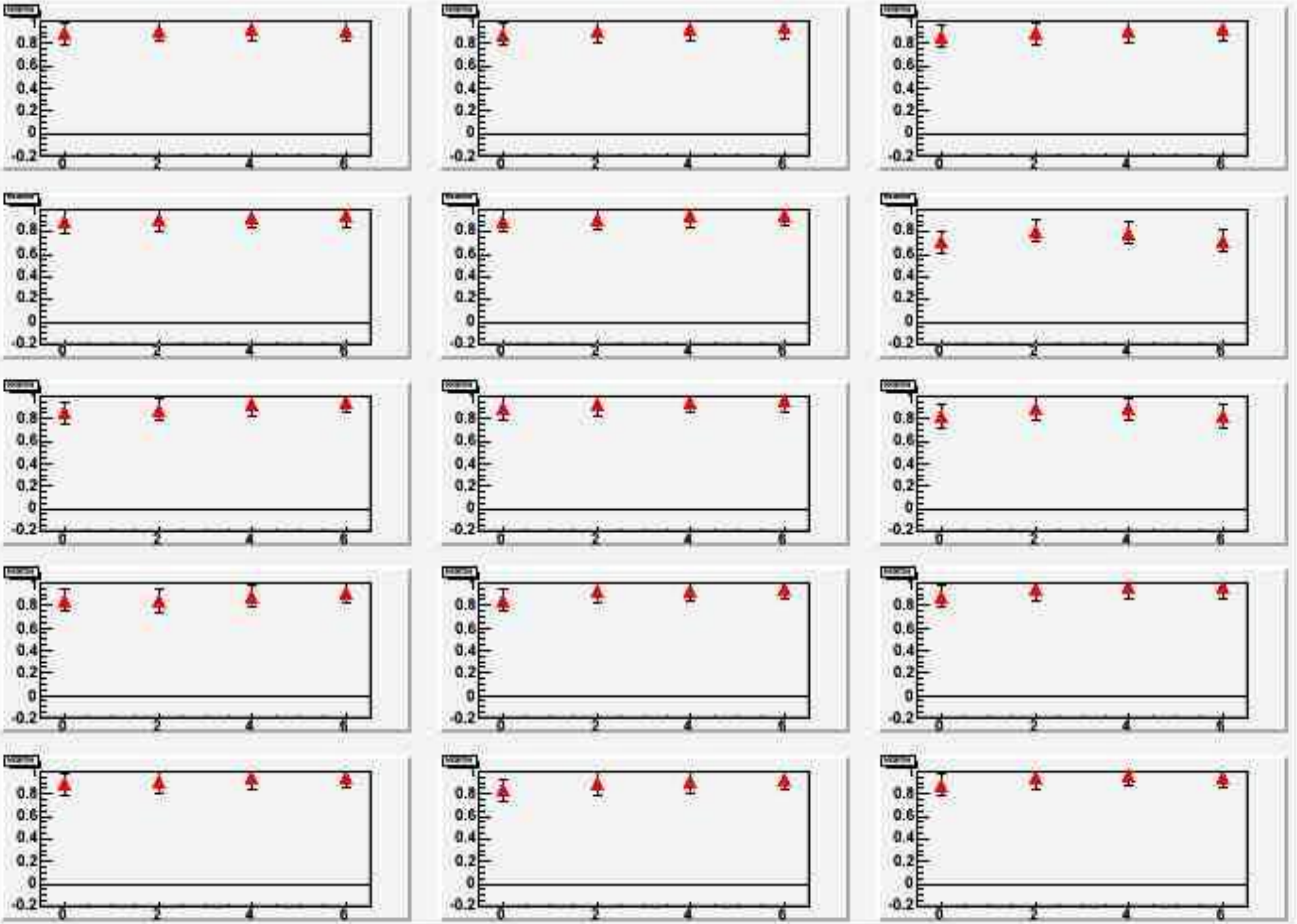
Correlation factor vs.Delay - Radometer@North – Press. cut 600mbar – Yscale -0.2->1.



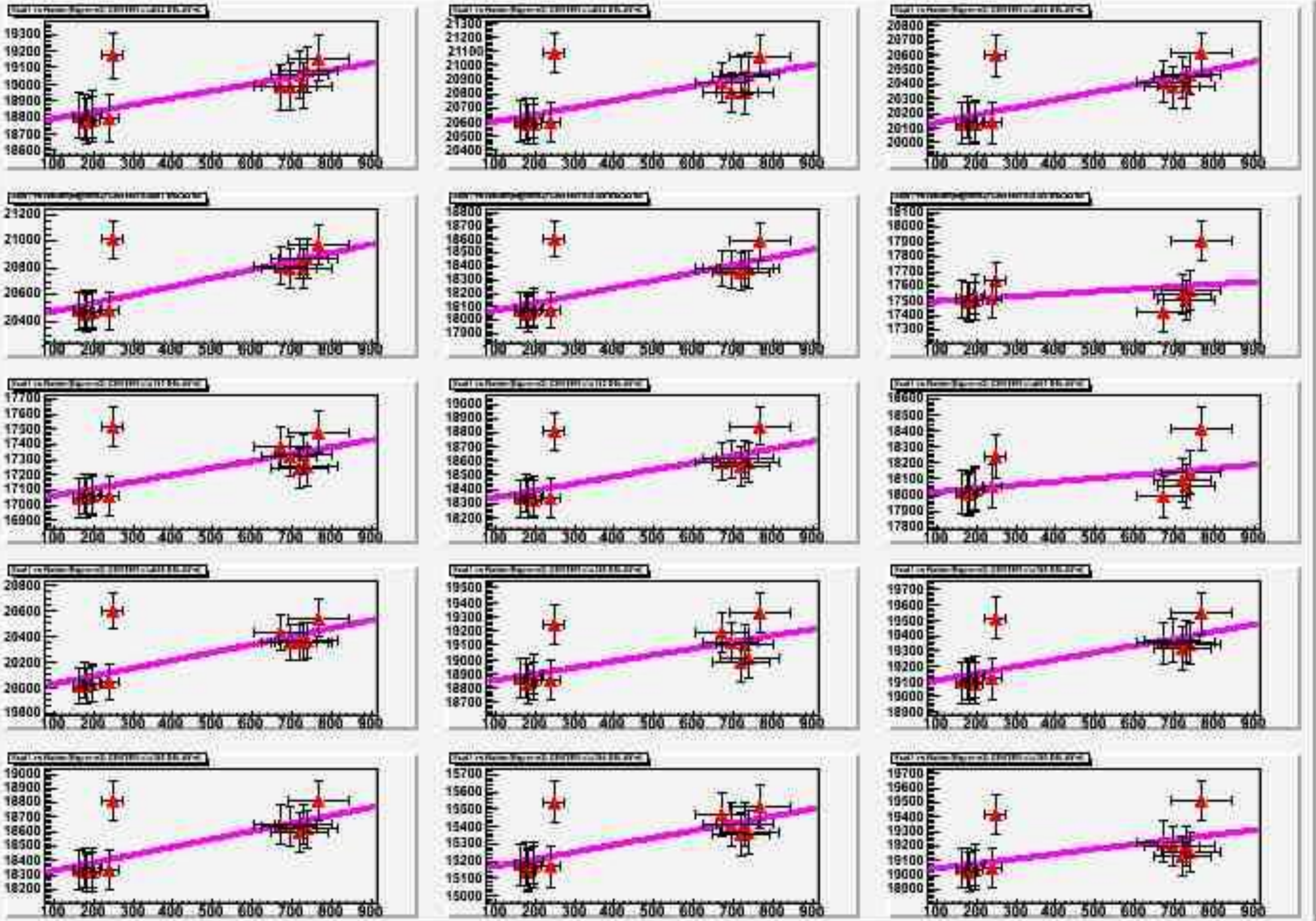
Correlation factor vs.Delay - Radometer@North – Press. cut 601mbar – Yscale -0.2->1.



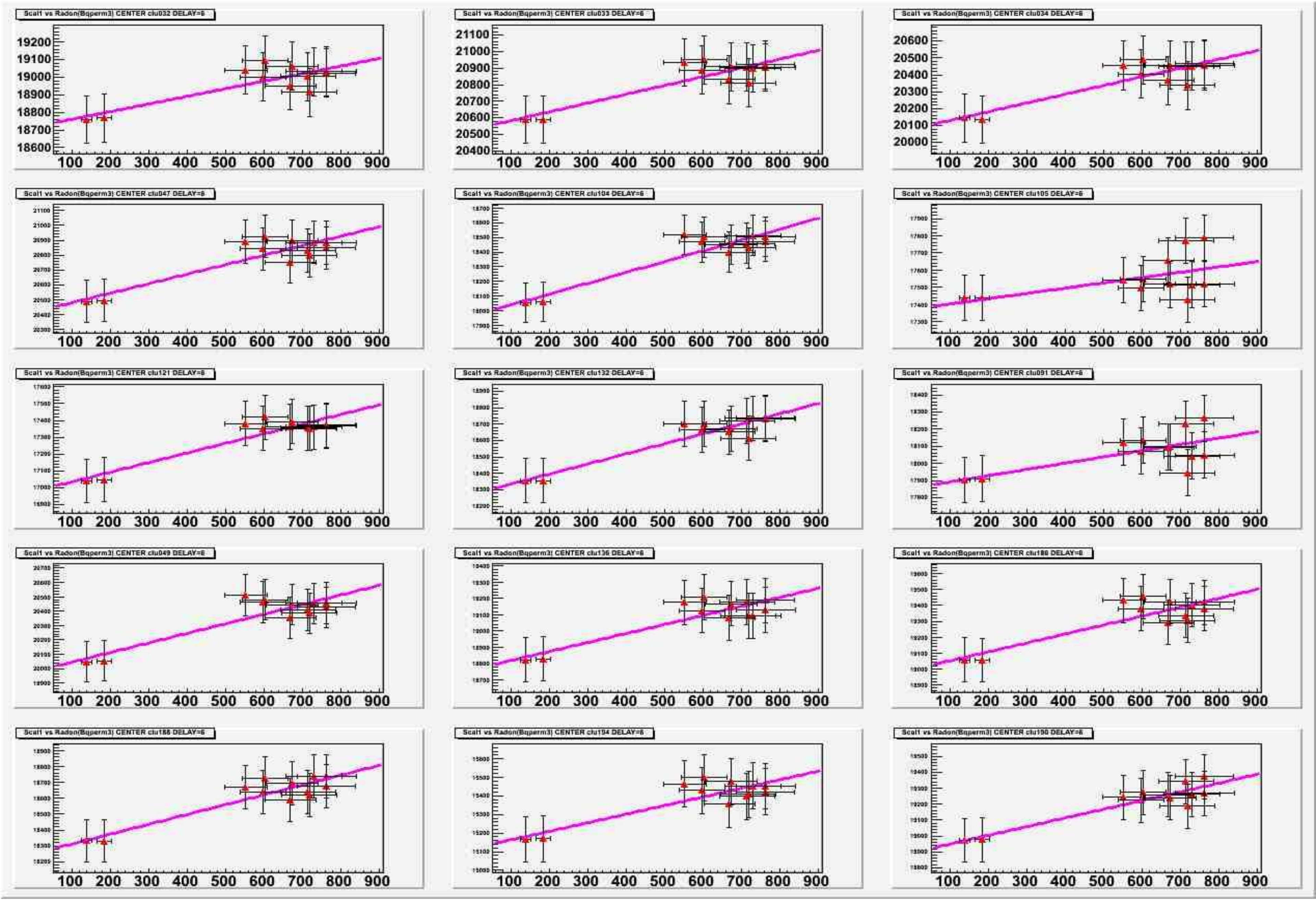
Correlation factor vs.Delay - Radometer@North – Press. cut 602mbar – Yscale -0.2->1.



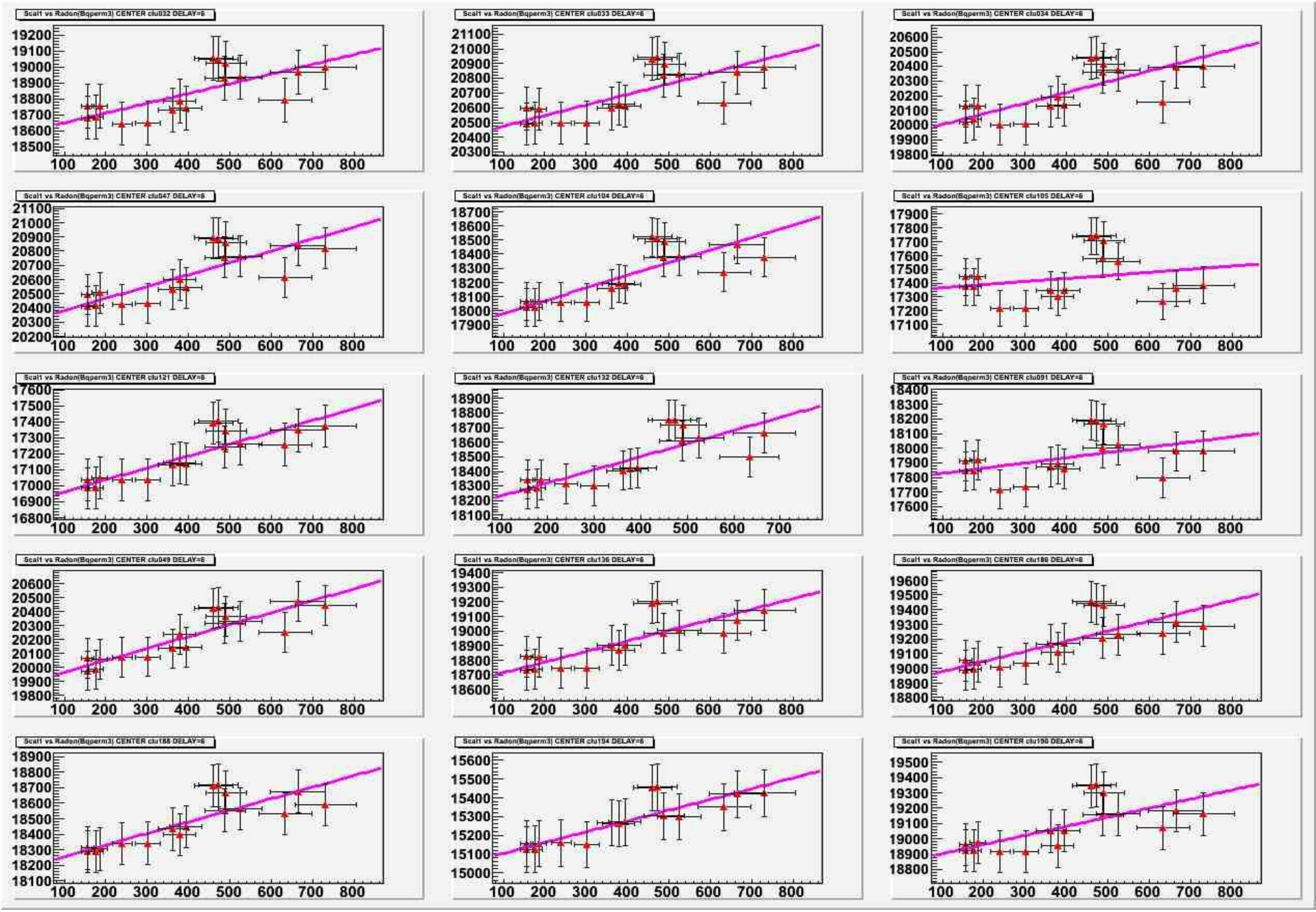
FIT Delay 3h – Radometer@carpet center – Press. cut 600mbar



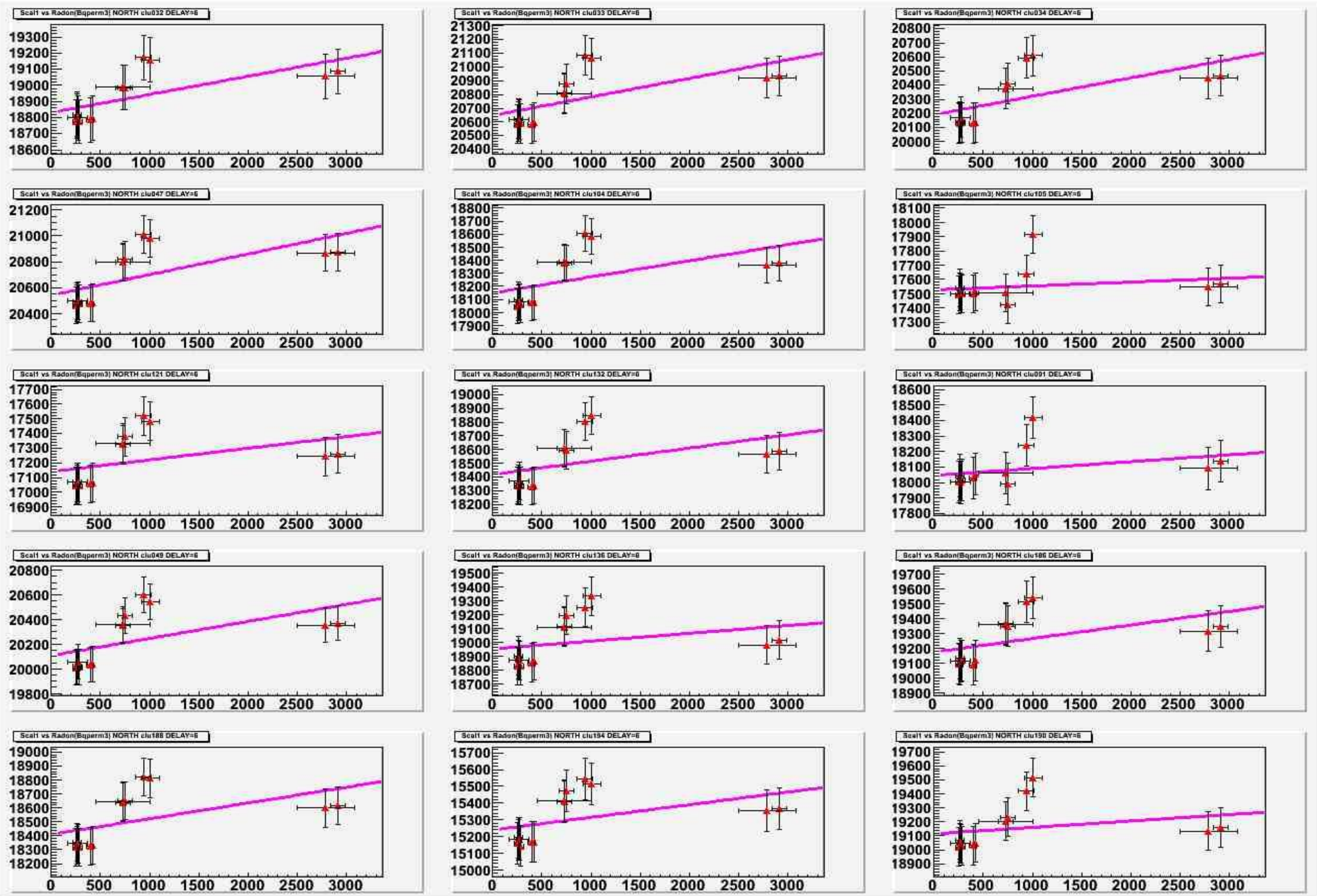
FIT Delay 3h – Radometer@carpet center – Press. cut 601mbar



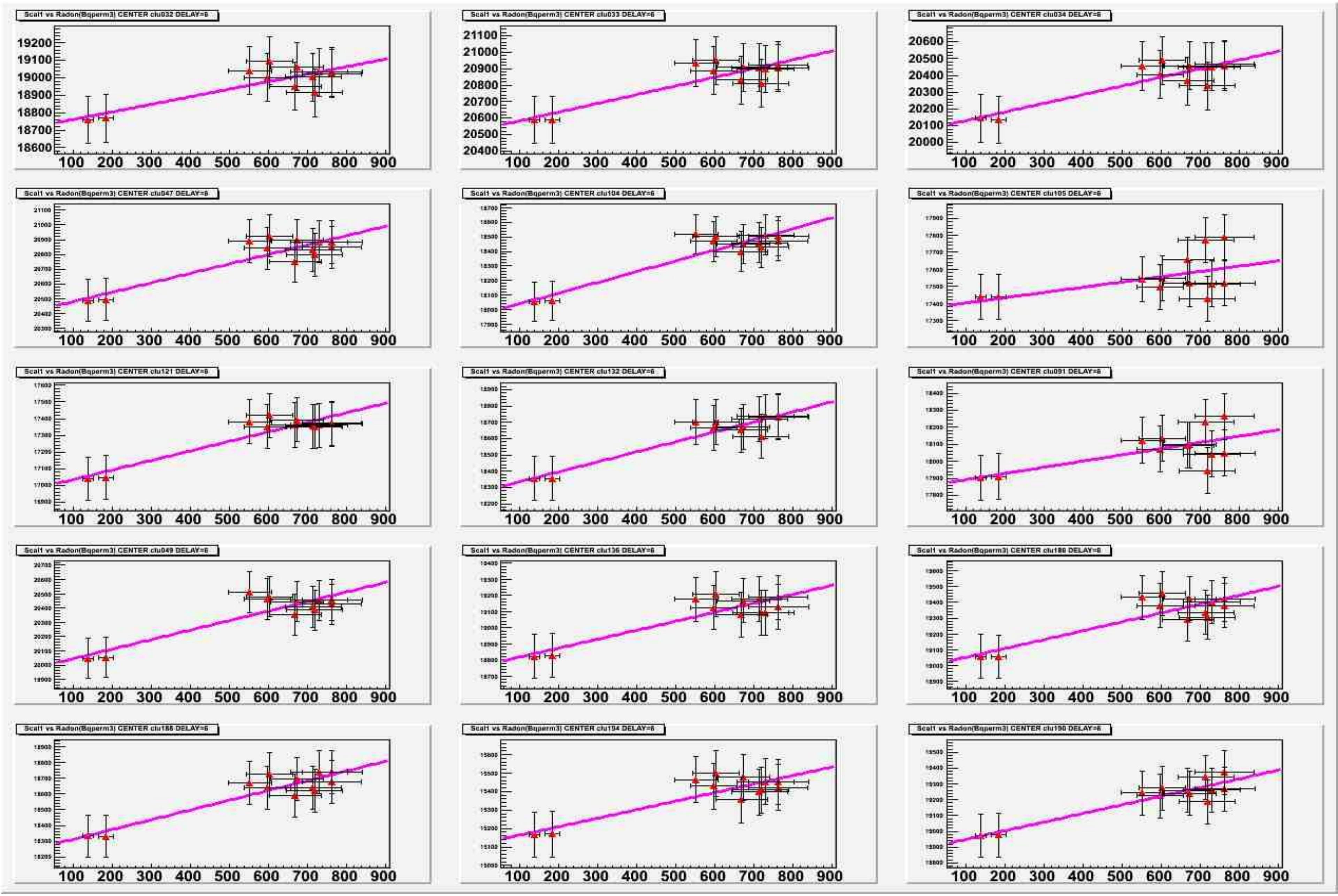
FIT Delay 3h – Radometer@carpet center – Press. cut 602mbar



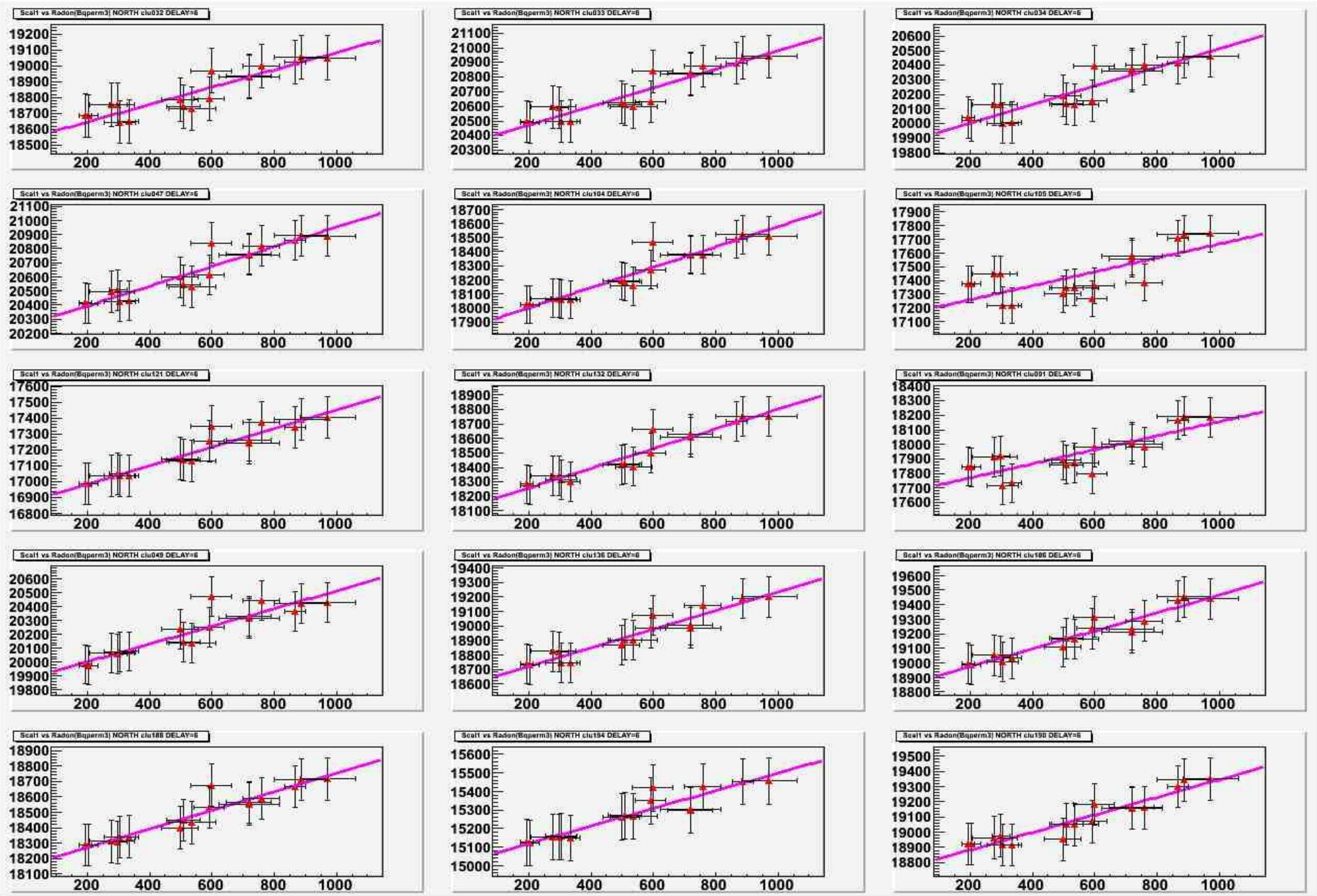
FIT Delay 3h - Radometer@North – Press. cut 600mbar – Yscale -0.2->1.



FIT Delay 3h - Radometer@North – Press. cut 601mbar – Yscale -0.2->1.

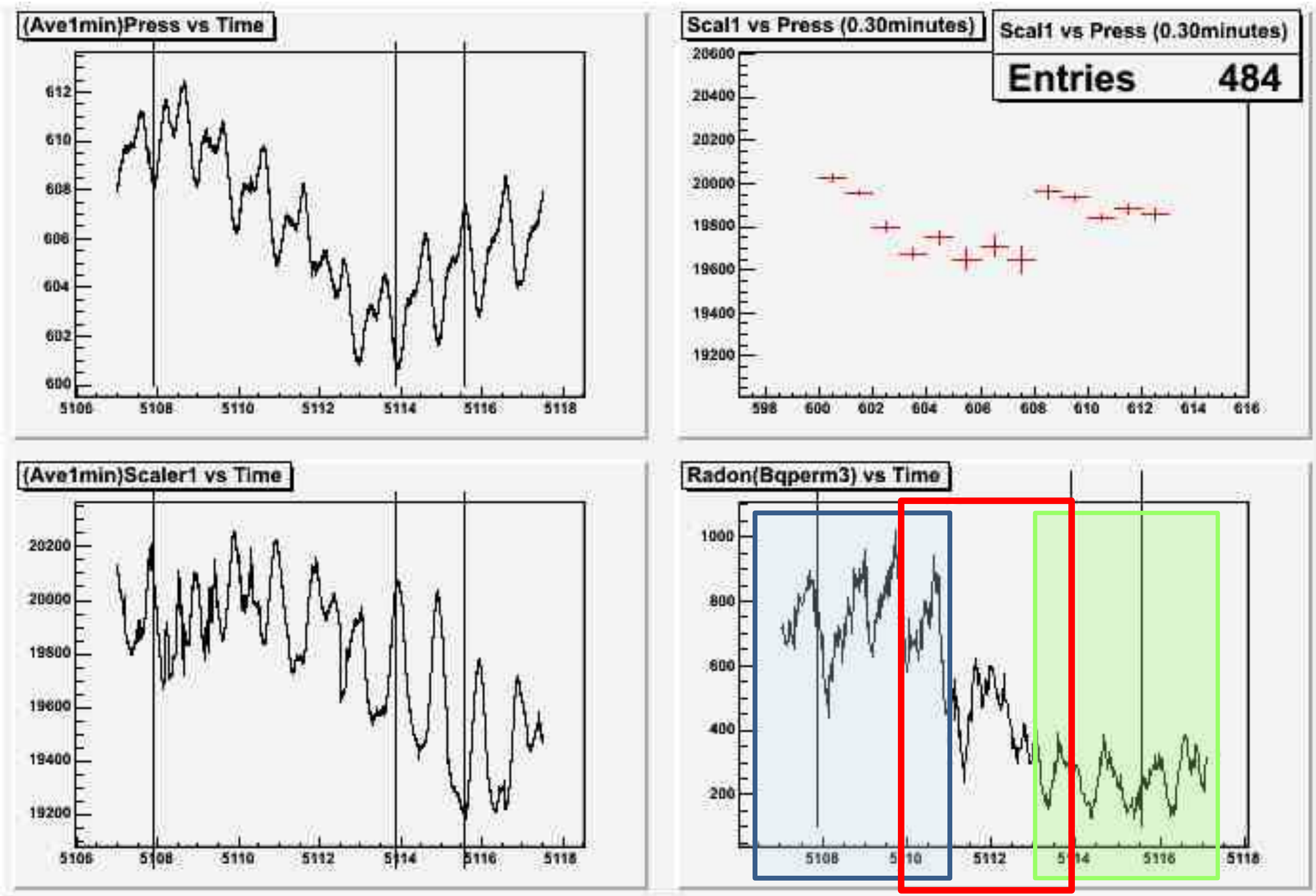


FIT Delay 3h - Radometer@North – Press. cut 602mbar – Yscale -0.2->1.

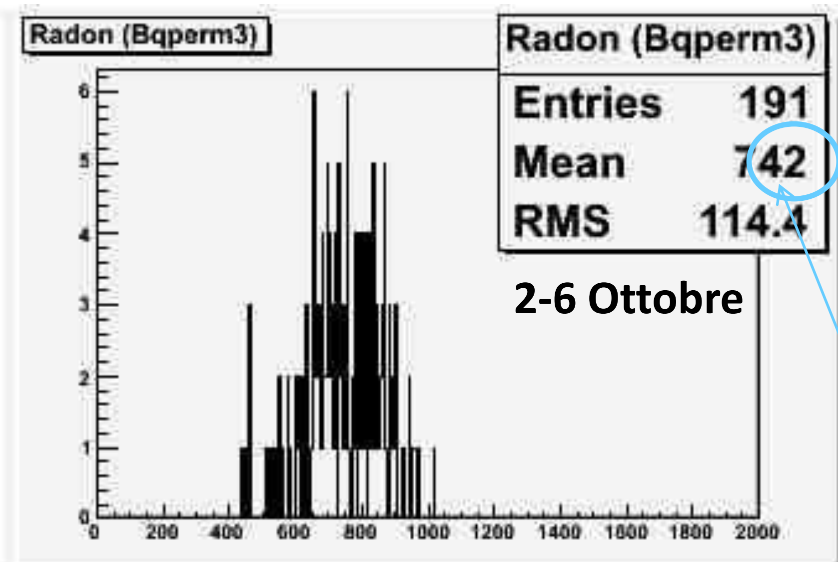


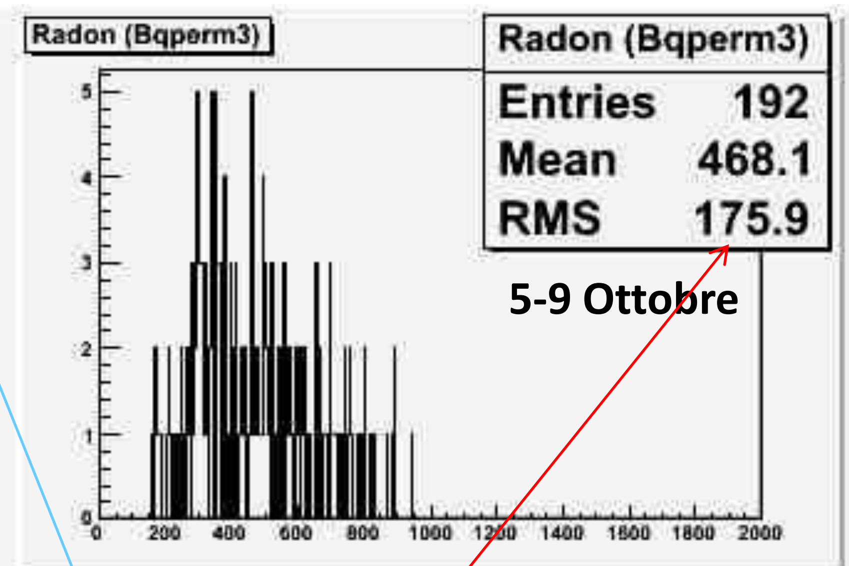
Correlazioni Scaler1 – Pressione

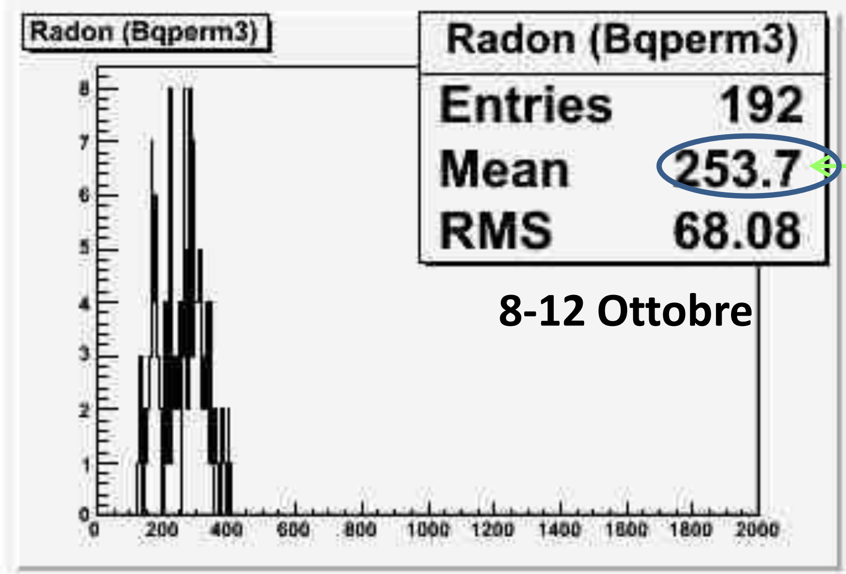
2/10/2009 – 12/10/2009 (10 giorni)



Concentrazione radon nei tre periodi



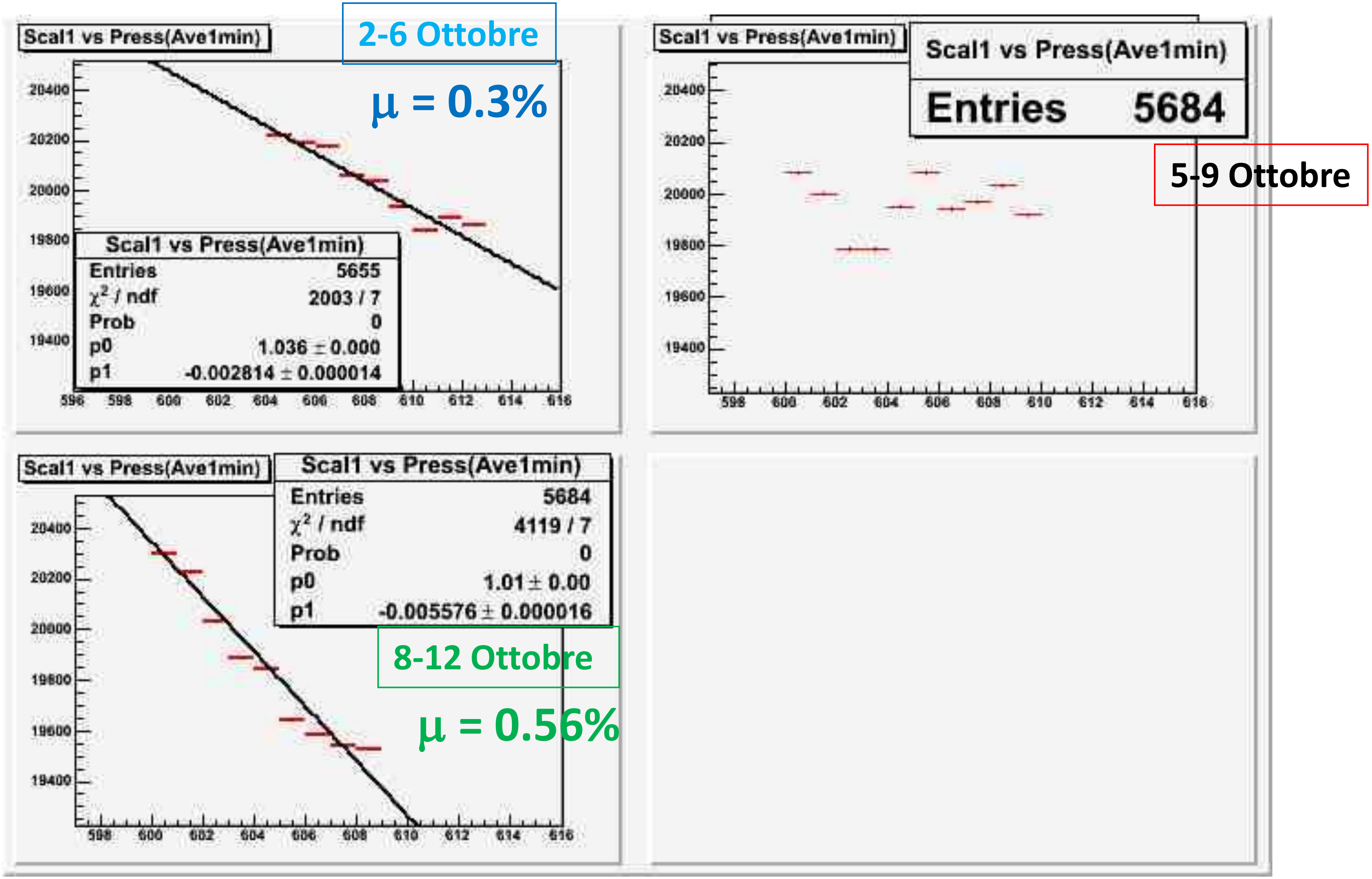




Media più alta nel primo periodo !!!
(più fondo da Radioatt. Naturale)

Varianza più ampia nel secondo periodo
(maggiori variazioni nei conteggi)

Dipendenza Scal1 vs. Press nei tre periodi



Dipendenza Scal2 vs. Press nei tre periodi